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MANUAL

OF

HUMAN OSTEOLOGY

BY

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ILLUSTRATED WITH 178 FIGURES, MANY IN COLOURS

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PREFACE

THIS *Manual* has been written for use in the Department of Practical Anatomy, and it is intended that the student, as he reads it, should have before him the parts of the skeleton described. The order in which the parts are dealt with follows a plan which has been found to work satisfactorily in practice.

With regard to the vexed question of terminology it will be noticed that throughout the text the names adopted by the Basle Nomenclature Committee have been printed in **black type,** but that other names, in frequent use, are also given. These latter are printed in *italics*, or in the type used for the text. It is hoped that by this means confusion will be avoided, and that the reader will become familiar with the international names, even if, in some cases, he prefers to adhere to the older English terms.

All the illustrations have been drawn by Mr. J. T. Murray, so well known as an anatomical artist, to whom I am deeply indebted for the great trouble he has taken to produce accurate and instructive figures. The drawing from an X-ray photograph of the upper end of the femur is from a photograph by Dr. W. S. Haughton, and has already been used to illustrate a paper in the *Journal of Anatomy and Physiology*; it is reproduced by the kind permission of the Editors of the *Journal*.

To Professor E. J. Evatt, of Winnipeg, my thanks are due for valuable suggestions and much assistance in correcting the text. I have also most gratefully to acknowledge the kind help I have received from Doctors T. P. C. Kirkpatrick, A. A. McConnell, and J. R. D. Holtby, who have each carefully read and corrected the proofs.

The Index is the work of Dr. M. R. Drennan, of Edinburgh University, and it is believed that it will add materially to the usefulness of the Manual. It will be noticed that it contains references not merely to the text, but also to the figures where the structures mentioned are illustrated.

In conclusion, I desire cordially to acknowledge the courtesy of the Publishers and of their Medical Editor, Mr. J. Keogh Murphy, F.R.C.S., who have most kindly met my wishes by every means in their power.

73 Grosvenor Road,
Dublin,
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MANUAL

OF

HUMAN OSTEOLOGY.

THE SKELETON.

BEFORE beginning the study of the individual bones which compose the human skeleton, the student should devote some time to make himself familiar with the general arrangement and plan of the parts in the mounted, or articulated, skeleton. He will notice that the *backbone*, or *columna vertebralis*, forms an axis of support for the neck and trunk, and that it ends above at the under aspect of the skull, and below in the rudimentary tail, or *os coccygis*. The vertebral column, in its upper part, is composed of numerous segments, jointed together, and movable upon one another to a slight extent during life; in its lower part, the segments are fused together to form a bony mass—the *os sacrum*. In the living subject, the part of the backbone which lies above the sacrum is flexible, and can be bent to a considerable degree from side to side, or backwards and forwards. Each of the segments of the columna vertebralis is called a *vertebra*, and is, in reality, an irregularly-shaped ring, the foramen, or cavity, of which is more or less rounded. The foramen which traverses each vertebra lies immediately below the foramen in the vertebra above, hence it follows that the vertebral column encloses a bony canal which runs throughout its length, from its upper end almost as far as the beginning of the rudimentary tail formed by the coccygeal vertebrae. This canal is called the *canalis vertebralis*, and encloses a portion of the central nervous system called the spinal cord.

The *skull* is placed upon the upper end of the vertebral column. The student will readily recognize that the skull consists of an upper and posterior portion forming a somewhat globular box, called the *cranium*, and of a part below and in front, forming the skeleton of the *face*. The cavity of the cranium contains the brain, and in the under aspect, or floor, of the cranium there is a large foramen placed immediately over the canalis vertebralis, through which the spinal cord and the brain become continuous. The greater part of the face is composed of bones, which surround and support the eyes, the nasal chambers, and the mouth cavity.

Immediately below the neck, or cervical region of the columna vertebralis, the *ribs* and the *sternum* form the cage-like wall of the chest cavity, or *thorax*, within which during life the lungs and the heart are situated.

The name *pelvis*, or *pelvic girdle*, is applied to the massive skeleton of the lower part of the trunk, which affords a firm region of attachment for the lower limbs, and a rigid connexion by means of which the weight of the body is transmitted to the ground through the legs.

At a glance it is apparent that, in general plan, the skeleton of the arm and leg closely resemble one another; although, when the comparison is pushed into details, the differences are very striking. Each of the subdivisions of the upper extremity has its counterpart in the lower: the upper arm bone, or *humerus*, is represented by the thigh-bone, or *femur*; the bones of the forearm, *radius* and *ulna*, by the bones of the leg, *tibia* and *fibula* respectively; the somewhat cubical bones of the wrist, or *carpal bones*, by the more massive bones of the ankle and foot, the *tarsal bones*; finally, the remaining bones of the hand and foot are disposed in a strikingly similar plan, and constitute the *metacarpals* and *phalanges* of the fingers and the *metatarsals* and *phalanges* of the toes.

Perhaps the most noticeable differences in plan are to be observed in the regions where the upper and lower extremities are connected with the trunk. The lower limb is, as we have seen, connected to the rigid pelvic girdle formed on each side by the massive hip-bone—*os coxae* or *innominate bone*. The os coxae is united to its fellow in front and to the os sacrum behind. In contrast with this arrangement, we find that the upper limb is connected to the trunk through a more lightly constructed *shoulder girdle* composed of two movable portions—the shoulder-blade, or *scapula*, and the collar-bone, *clavicle*, or *clavicula*. Unlike the pelvic girdle, the shoulder girdle is not fixed to the vertebral column, but gains its support from the upper end of the sternum, with which the collar-bone is firmly connected.

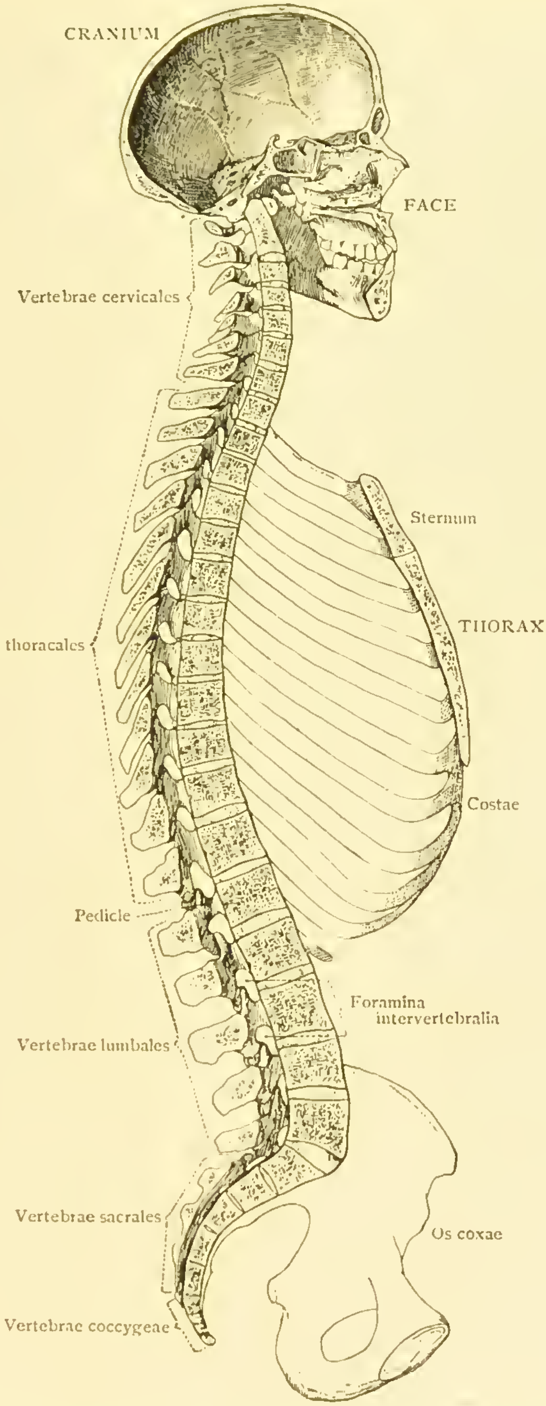

FIG. 1.—Sagittal section through the skeleton of the head and trunk; the cranial cavity and the whole length of the canalis vertebralis have been opened up.

DESCRIPTIVE TERMS.

During his survey of the skeleton, it will have become obvious to the student that it would be possible to divide the skeleton into equal right and left portions by sawing it in a vertical plane, beginning at the top of the skull, and cutting downwards through the vertebrae and the sternum to the os coccygis or tail-bone. The vertical plane which would be determined by such a cut, or section, is spoken of as the *median* or *mesial plane*; and since organisms which are capable of division by such a plane into right and left halves are said to be bilaterally symmetrical, we recognize that the human skeleton exhibits *bilateral symmetry.* If we suppose the head, neck, and trunk to have been cut through in the manner described, the lines on the front and on the back of the body along which the section would pass are called *ventral* and *dorsal*, or anterior and posterior, *middle lines.* Every section or plane which passes through the body in a direction parallel to the median plane is spoken of as a *sagittal section*, or *plane*; and all vertical planes which lie at right angles to these and to the mesial plane are spoken of as *frontal*, or *coronal.*

It is important at once to clearly understand that the various parts of the skeleton are described as occupying the positions in which they are found when the subject is standing upright, with the arms hanging by the sides and the thumbs pointing outwards away from the median plane. The *normal* or *proper position* of any bone is the position which it occupies in the erect body with the arms so placed. The terms *medial* or *internal*, and *lateral* or *external*, are used to denote nearness to, or distance from, the median plane. Thus, a part of the skeleton which is nearer to this plane is said to lie medial, or internal, to a part further from it; and a part which is situated further away is described as lying lateral, or external, to a part nearer the median plane. The terms *superior* and *cephalic* are employed to indicate that the structures to which they are applied lie nearer to the head than those which are described as *inferior* or *caudal.* In like manner, *anterior* and *ventral* are used to denote nearness to the front of the body, and *posterior* and *dorsal* proximity to the back.

The manner in which the terms just described are used will become more evident if, for example, we notice how they might be applied to such a bone as the sternum, or breast-bone. This bone occupies the *middle line* on the *ventral aspect* of the trunk, and possesses *anterior* and *posterior* surfaces, which are limited by two *lateral* borders. Its *superior* or *cephalic* extremity supports the clavicles, and its *inferior* or *caudal* end lies in the angular interval between the lower costal arches.

It is, perhaps, well to state that the terms 'anterior', 'posterior', 'superior', and 'inferior' have up to the present time been usually employed in English textbooks of human anatomy; the equivalent terms, 'ventral,' 'dorsal,' 'cephalic,' and 'caudal,' have been introduced more recently from comparative anatomy, and in some ways they are preferable, inasmuch as they are equally applicable to man and other vertebrate animals.

It will be evident from what has already been said that the terms 'internal' and 'external' do not necessarily indicate distance from, or nearness to the surface of the body. These latter ideas are expressed by the special terms *deep* and *superficial.*

There are a few descriptive terms which are used with special reference to the parts of the upper and lower limbs. *Proximal* and *distal* denote nearness to, or distance from the trunk. Hence, for example, each of the long bones of the arm and leg has a proximal and a distal extremity; and we also speak of the phalanges of the fingers and toes as lying proximal and distal to one another. Also in the case of the arm and hand, it is customary to speak of *radial* and *ulnar* borders—the former lying on the lateral, the latter on the medial aspect of the limb; in the leg and foot we have *tibial* and *fibular* borders corresponding to the medial and lateral aspects. The student will notice that the thumb lies on the radial side of the hand, and the great toe on the tibial side of the foot.

COLUMNA VERTEBRALIS.

The **columna vertebralis**, or vertebral column, is composed of thirty-three segments, or **vertebrae**, which remain separate and are movable in the upper part, but in the lower part of the column become fused together before adult age is reached. Since the column extends from the under aspect of the skull downwards through many regions of the body, e.g. neck, chest, abdomen, pelvis, and tail, it is customary to subdivide it into portions corresponding to these regions. The names of the subdivisions and the number of vertebrae which, in the human skeleton, belong to each are as follows :—

Cervical	7	24 Movable Vertebrae.
Thoracic	12	
Lumbar	5	
Sacral	5	9 Fixed Vertebrae.
Coccygeal	4	

A glance will show that the coccygeal vertebrae are of small size, and simple in outline ; this, coupled with the easily observed great variability which occurs in their shape and mode of fusion, leads us to recognize that in man the tail vertebrae represent, in merely vestigial form, the more perfectly developed structures found in many other animals. The fusion of the vertebrae and the modifications which they undergo in the sacral region are of much importance, as it is through the massive os sacrum that the weight of the parts above is transmitted to the lower limbs—the fixed vertebrae in this region affording a firm support for the pelvic girdle.

Having provided himself with a series of isolated vertebrae, representing the various regions of the columna vertebralis, the student should begin the detailed study of the column by noting the form and parts of an individual vertebra. It is well, in the first instance, to begin with one of the larger vertebrae.

FORM AND PARTS OF A VERTEBRA.

An examination of the vertebrae makes it evident that they are modelled on the same general plan, although it is true that the upper differ markedly from the lower free vertebrae, and that the vertebrae of the regions enumerated above exhibit special characters, which enable us to determine to which of the various subdivisions of the vertebral column they belong.

The general plan includes the characters which are common to the various vertebrae, and combining these we may construct a *typical vertebra* with which to compare and contrast the vertebrae of the cervical, thoracic, lumbar, and sacral regions.

A typical vertebra has the form of a ring, bounded anteriorly by a cylindrical or disc-like mass of bone called the **corpus vertebrae**—body, or centrum—and completed by an arch of bone to which the name **arcus vertebrae**, or neural arch, is applied. The enclosed foramen is called the **foramen**

vertebrale, and forms a segment of the canalis vertebralis. The upper and lower surfaces of the corpus vertebrae are nearly flat, and are very firmly connected to the lower and

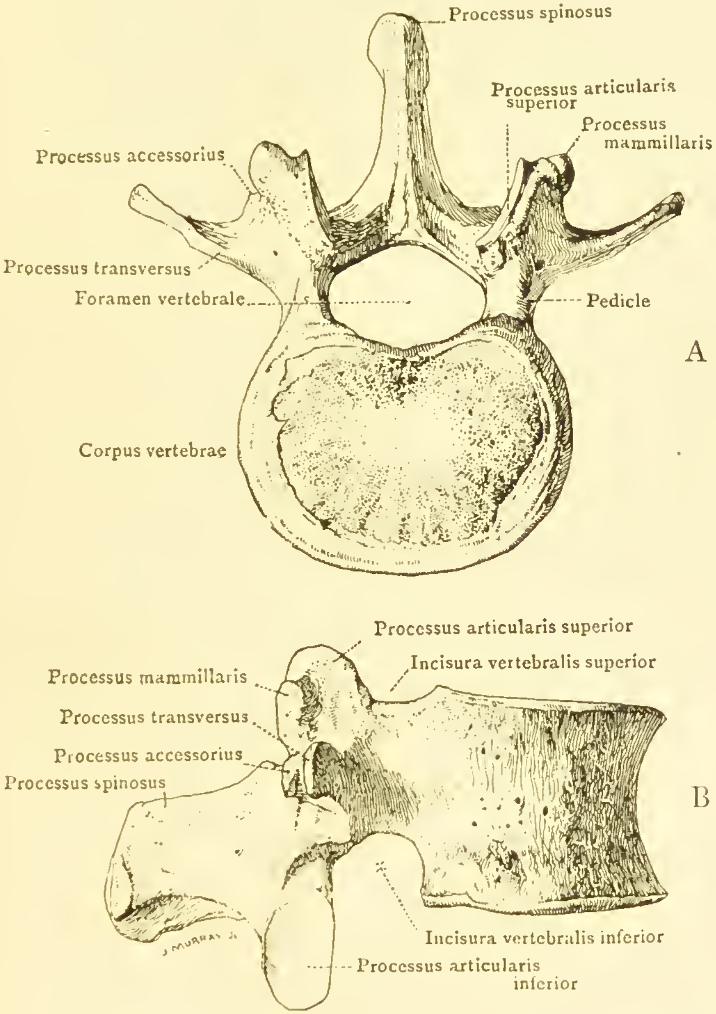

FIG. 2.—Lumbar vertebra; A, from above; B, from the right side.

upper surfaces of the vertebrae above and below by thick, plate-like, somewhat elastic pads called *intervertebral discs*. These intervening discs are sufficiently elastic to permit a small amount of movement between each two vertebrae, and their thickness is such that they form a considerable portion, about one-fourth, of the entire length of the columna vertebralis in the living subject. The superimposed bodies of the vertebrae and the intervening intervertebral discs form the weight-carrying part of the vertebral column.

The arcus vertebrae springs by two pillar-like portions, the *pedicles* or **radices arcus vertebrae**, from the posterior aspect of the body, and is completed posteriorly, behind the foramen vertebrale, by the union of two bony plates called *laminae.* These latter plates are connected along their upper and lower edges by elastic ligaments with the laminae of the vertebrae above and below. In this way the **canalis vertebralis**, which surrounds the spinal cord, is closed in posteriorly by the vertebral laminae and their connecting ligaments. The anterior wall of the canal is formed by the bodies of the vertebrae and the intervertebral discs.

Attached to the arch of each vertebra are a number of projecting pieces of bone, or processes. One of these, the **processus spinosus**, is median in position, and springs from the junction of the laminae posteriorly. The others are attached in the region where the pedicle joins the lamina, and are three in number on each side. These paired processes are named as follows :—

processus transversus—attached laterally at the junction of the pedicle and lamina, and directed outwards ;

processus articularis superior—attached to the upper aspect of the arch immediately behind the pedicle, and directed upwards ;

processus articularis inferior—attached to the lower aspect of the arch just behind the pedicle.

The articular processes are so called because they carry articular facets by means of which the arch of the vertebra articulates with the arches of the vertebrae above and below. These facets have a characteristically smooth appearance, and during life they are covered by a thin layer of articular cartilage, which enables the facets of one vertebra to glide evenly on those of the vertebrae with which it is connected.

If we examine a vertebra from its lateral aspect, we recognize that there is a notch, or hollow, between the inferior articular facet and the posterior aspect of the lower part of the body, and a similar shallower depression between the superior articular facet and the upper part of the body. These notches, spoken of as the *superior* and *inferior vertebral notches*, **incisura vertebralis superior** and **inferior**, are separated from one another by the vertical thickness of the pedicle. When the vertebrae are articulated with one another, and occupy their normal position, the notches form a series of **foramina intervertebralia** which lie between the pedicles of each pair of vertebrae and serve as exits from the canalis vertebralis for the passage of the spinal nerves that come off from the spinal cord. The foramina intervertebralia are well seen in the articulated skeleton, especially in the lumbar and thoracic regions.

VERTEBRAE CERVICALES.

The vertebrae of the neck are, as we have seen, seven in number. The first and second cervical vertebrae differ markedly from all the other free vertebrae, and until it is critically examined, the first, especially, appears to show but few points in agreement with the plan of the typical vertebra. We shall postpone the examination of the first two until we have studied the other cervical vertebrae. The third, fourth, fifth, and sixth **vertebrae cervicales** are all built upon the same plan, and the seventh, although it shows certain peculiarities which enable us to identify it, does not differ very much from them.

The student will readily recognize that every cervical vertebra possesses a foramen in each of its transverse processes, and further that the presence of this, the **foramen transversarium**, enables him at a glance to distinguish the cervical from all the other vertebrae.

The **corpus**, or body of a cervical vertebra, is distinctly wider from side to side than from before backwards, and its upper surface is not flat as in the other vertebrae but somewhat concave from side to side with upwardly projecting lateral edges. The anterior part of the upper surface slopes a little downwards and forwards, and is overhung by the anterior and lower part of the body of the vertebra above. If the student places two of these cervical vertebrae so that they articulate with one another in the normal manner, he will notice that the bodies interlock in such a way, that the raised lateral edges of the vertebra below enclose between them the body of the vertebra above, and that the upper vertebra has a lower projecting anterior edge which overlaps to a slight extent the body of the vertebra below. This interlocking of the bodies of the vertebrae is a peculiarity of the cervical region of the vertebral column.

The **foramen vertebrale** is of larger size in the cervical region than in the other subdivisions of the vertebral column.

It is approximately triangular in outline, and the *laminae* which bound it posteriorly are long and slender.

The **processus spinosus** is short, directed horizontally backwards and, usually, divided by a cleft into right and left tubercles.

The *pedicles* are short and directed outwards as well as backwards. They are attached to the body nearly as far from its

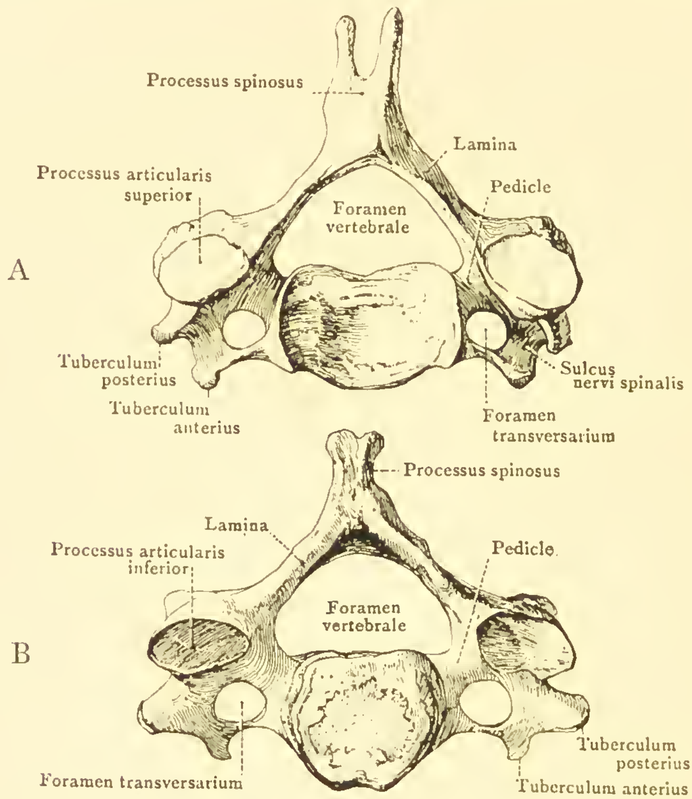

Fig. 3.—Cervical vertebra; A, from the upper; B, from the lower aspect.

upper as from its under surface and hence the upper and lower vertebral notches, or **incisurae vertebrales**, are of approximately equal depth.

The superior and inferior articular facets are situated upon the upper and lower surfaces of short columns of bone formed at the junction of the pedicles and laminae. The upper facets look upwards as well as backwards, and the lower downwards as well as forwards. When a number of cervical vertebrae are placed in position and articulated with one another in the normal manner, the student will notice that the entire weight of the head is not transmitted through the bodies of the vertebrae, but that part is carried by the short columns of bone, the upper and under surfaces of which are formed by

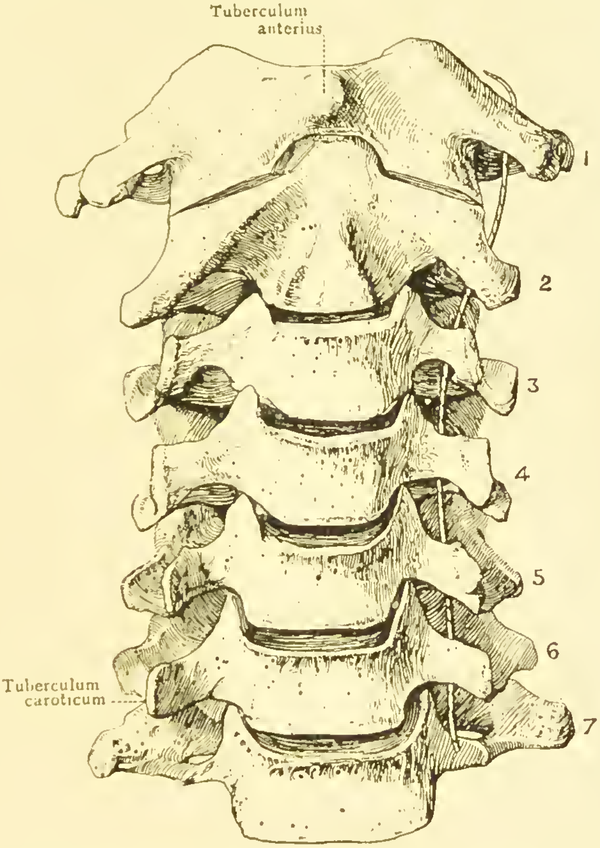

FIG 4.—The vertebrae cervicales viewed from in front. The interlocking of the bodies of the vertebrae is well seen. A piece of twine has been passed along the course of the left arteria vertebralis.

the articular facets. A glance at the articulated vertebral column will show that in the dorsal and lumbar subdivisions the articular processes of the vertebrae have not this weight-carrying function, which is, indeed, a peculiarity of the cervical region.

Attention has already been called to the **foramen transversarium** present in the transverse process of every cervical vertebra. It transmits the vertebral vein and, except in the case of the seventh cervical vertebra, the foramen also gives passage to the vertebral artery, which passes upwards through the transverse processes to enter the cranial cavity. The foramen transversarium is bounded in front by a slender bar of bone known as the *costal process*. This is fixed at its inner end to the body of the vertebra and free at its outer end, where it forms a little projection, the **tuberculum anterius**, of the transverse process. Behind and external to this tubercle lies the **tuberculum posterius** which is more closely related to the articular process. The bar of bone which connects the anterior and posterior tubercles, and forms the outer wall of the foramen transversarium, is deeply grooved on its upper aspect for a spinal nerve, which in its course passes outwards behind the vertically directed vertebral artery. The anterior bar of the transverse process is of interest morphologically as it represents a skeletal element which in the thoracic region is developed to form a rib. Occasionally in the case of the seventh, and more rarely in the sixth cervical vertebra, it may form a separate mass of bone—a *cervical rib*—and by its presence may give rise to pressure on the nerves of the arm. The anterior tubercle of the sixth cervical vertebra is very prominent, and the projection which it forms is called the **tuberculum caroticum**, since it is possible to compress the common carotid artery against it in the living subject, when it is desired to control haemorrhage from this vessel or from its branches.

The **vertebra prominens**, or *seventh cervical vertebra*, is easily identified by its long, horizontally directed processus spinosus. This process is not bifid, as is usually the case in the third, fourth, fifth, and sixth vertebrae, but forms a knob-like projection, readily felt in the lower part of the neck of the living subject. The processus transversus is very variable in its development; its anterior bar may be small, or of considerable size, and occasionally, as we have seen, forms a separate bone, or cervical rib. The foramen transversarium, usually smaller than in the other cervical vertebrae, is often subdivided and transmits the vertebral vein but not the corresponding artery.

THE ATLAS AND THE AXIS VERTEBRA.

The *first* and *second cervical vertebrae* differ markedly in their appearance from all the others. The first is named **atlas** from its position immediately beneath the globe formed by the head, and the second is called *axis* because it possesses a pivot-like process round which the first vertebra and with it the head can be rotated. (The name **epistropheus** is applied to the second vertebra by the Basle Nomenclature Committee.)

An examination of the **atlas** shows that the corpus vertebrae, or centrum, is absent, that the processus spinosus is reduced in size to a mere tubercle, and that the foramen vertebrale is larger than in the case of any other vertebra. This foramen in the atlas not merely affords a passage for the upper part of the spinal cord, but it also lodges

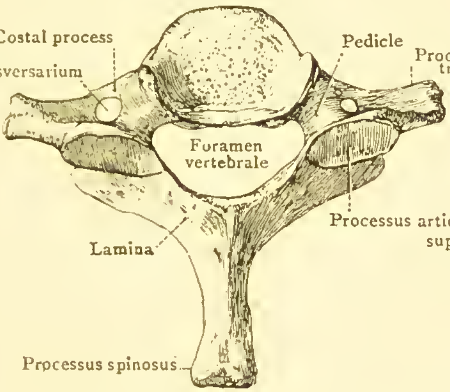

FIG. 5.—Vertebra prominens viewed from above.

the peg-like process of the second vertebra, round which the atlas is rotated when the head is turned from side to side. The term **dens**, or more frequently *odontoid process*, is applied to this projection of the second vertebra. The large foramen vertebrale of the atlas is bounded by an **arcus anterior**, an **arcus posterior**, and on each side by a **massa lateralis**, which carries the large articular surfaces and the widely outstanding transverse processes.

If the first and the second vertebrae be articulated, it will be noted that the odontoid process occupies the anterior part of the foramen vertebrale of the atlas, and it may at once be stated that the odontoid process is in reality the body of the first vertebra, which during the course of development has become fused to the upper surface of the second. Before attempting to articulate these two vertebrae the student must be careful to identify the under aspect of the atlas, which is readily recognized by the two large, almost flat, and nearly circular facets which it carries for articulation with the axis. Having placed the two bones in position, the manner in which the first vertebra can be rotated round the odontoid process of the axis may be conveniently studied. The odontoid process is smooth and articular on its anterior aspect and rubs against a smooth

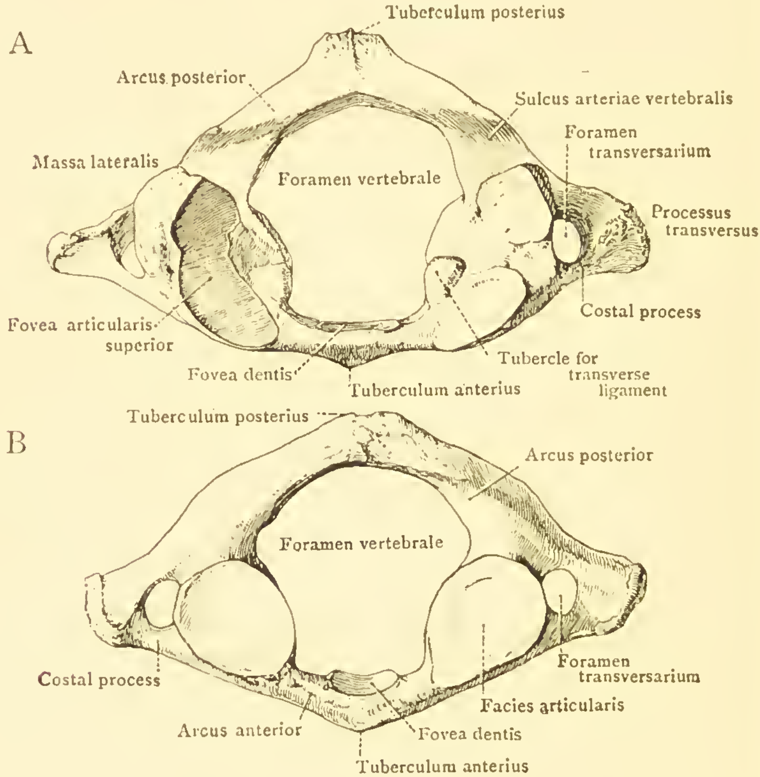

Fig. 6.—The atlas; A, from above; B, from below. On the right side of the figure the fovea articularis superior is subdivided into anterior and posterior portions.

depression, the **fovea dentis,** on the arcus anterior of the atlas. Backward displacement of the odontoid process is prevented by a strong ligament which divides the foramen vertebrale of the atlas into a larger posterior portion for the spinal cord, and a smaller anterior part for the odontoid process. This ligament is called the transverse ligament, and its point of attachment is marked on each side by a little tubercle, placed on the rough area below and to the inner side of the large superior articular surface of the atlas. The odontoid process during life is held firmly between the arcus anterior and the transverse ligament. The anterior aspect of the odontoid articulates, as we have seen, with the arcus anterior of the atlas, and the posterior aspect of the process is articular for the transverse ligament.

The term **massa lateralis** is applied to the part of the atlas which bounds the foramen on each side. On its upper aspect lies the **fovea articularis superior**, oval in outline, concave, and nearer to the middle line in front than behind. The foveae articulares superiores of the atlas articulate with smooth projecting processes on the under aspect of the skull, called the occipital condyles. Each fovea is sometimes imperfectly, or more rarely completely, subdivided into an anterior and posterior portion, and is so placed that its outer edge is on a higher level than its inner margin. The student should articulate a skull with an atlas vertebra and carefully study the way in which the parts interlock: he will notice, from the form of the articulation, that dislocation is not likely to occur, and that while movement in an antero-posterior plane, and of a nodding nature, is permitted between the two bones, other movements at this articulation are extremely limited. He will notice also that when the head is turned from side to side the atlas vertebra moves with the head round the odontoid process of the axis.

The inferior articular facets of the atlas are placed on the under aspect of the massae laterales and are of large size, slightly concave, nearly circular in outline and directed downwards and inwards. Each articulates with a similar facet placed partly on the upper aspect of the body, and partly on the pedicle, of the axis.

Each processus transversus of the atlas springs from the outer side of the massa lateralis and is not bifid at its extremity. As in the other cervical vertebrae, the processus transversus is pierced by a foramen for the vertebral artery. It will be noticed that the interval between the tips of the transverse processes is greater in the case of the atlas than in any other of the neck vertebrae. In this way greater leverage is afforded to the powerful inferior oblique muscle which assists in rotating the atlas, and with it, the head on the axis. This muscle springs from the massive spine of the axis and is inserted into the processus lateralis of the atlas.

The **arcus posterior** of the atlas is longer than the arcus anterior, and it is usually compressed, or flattened, from above downwards. It carries in the middle line a small tubercle, the **tuberculum posterius**, which represents a rudimentary processus spinosus. The upper aspect of the arcus posterior is grooved for the vertebral artery, and in some cases the groove is converted into a bony tunnel, or foramen. This groove, the **sulcus arteriae vertebralis**, also lodges the first cervical, or sub-occipital, nerve which passes out between the lower part of the skull and the arcus posterior of the atlas. The groove for the artery and nerve lies just behind and to the inner side of the massa lateralis. The sinuous course of the vertebral artery in relationship to the atlas can be recognized even in the dry bone; the artery comes up through the foramen transversarium, winds backwards below the outer and posterior aspect of the upper articular facet on the massa lateralis, enters the groove on the arcus posterior and turns forwards and inwards in this groove to the inner side of the massa lateralis. The artery then turns upwards to enter the skull.

The **arcus anterior** is shorter than the arcus posterior and is less arched. It is flattened, or compressed, from before backwards and exhibits, as we have seen, a concave facet on its posterior aspect for the odontoid process of the axis. Anteriorly the arch carries a small **tuberculum anterius.**

In studying the mode of articulation, and the movements which take place between the atlas and the axis, we have already noted most of the important characters of the axis vertebra. The presence of the vertically placed peg-shaped *odontoid process* (**dens**) enables us to distinguish the axis from all other vertebrae. The process springs from the upper aspect of the body by a slightly constricted neck. It possesses an anterior facet, **facies articularis anterior**, for the anterior arch of the atlas, and a posterior facet, **facies articularis posterior**, for the transverse ligament already described. As we have seen, the process forms the pivot round which the first vertebra rotates when the head is turned from side to side. The summit of the odontoid process shows two sloping laterally placed surfaces from each of which a ligament passes to be attached to the skull at the inner side of the occipital condyle. These ligaments limit the amount of rotation of the head, and hence are called the check ligaments (ligamenta alaria). From the apex of the odontoid process a slender fibrous cord passes upwards to join the occipital bone.

The superior articular facets of the axis are flat, of large size and circular outline. It should be noticed that they are placed partly on the arch and partly on the body of the vertebra, and through them the weight of the head is transmitted to the rest of the vertebral column.

The transverse processes are short and not bifid. The foramen transversarium is directed outwards as well as upwards.

The processus spinosus is thick, strong, and massive, and deeply grooved on its under surface in the middle line.

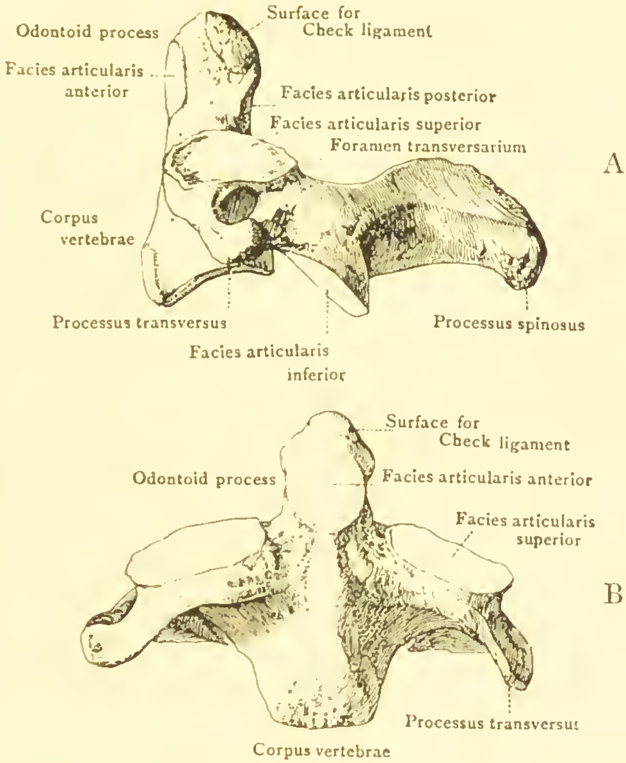

FIG. 7.—The axis, or second vertebra; A, from the left side; B, from in front.

The student will notice that there are no intervertebral foramina between the atlas and axis such as occur between the other vertebrae. The second cervical nerves pass out over the laminae of the second vertebra and below the posterior arch of the first, not through intervertebral foramina as in the case of the nerves lower down.

The under aspect of the axis resembles very closely the under surface of a typical cervical vertebra.

VERTEBRAE THORACALES.

The **vertebrae thoracales**, twelve in number, are readily recognized by the presence of facets for the heads of the ribs, situated on the sides of the bodies. On each of the upper ten thoracic vertebrae, facets may also be seen on the transverse processes for the tubercles of the corresponding ribs. The upper thoracic vertebrae differ very considerably from the lower, being of smaller size, and in general outline resembling the last cervical vertebra. The lower thoracic are larger and in form approximate to the upper lumbar vertebrae.

A vertebra from the middle thoracic region exhibits the characters of the series in the most striking manner. Having selected such a vertebra, the student will notice that the *body* is 'heart-shaped' in outline, and that its antero-posterior is greater than its transverse diameter. Further, the body is slightly deeper behind than in front, hence the thoracic portion of the columna vertebralis is concave on its anterior aspect, and the size of the thoracic cavity is materially increased. On each side of the body of the vertebra two articular facets will be noticed, one near the upper, and the other near the lower edge. These facets, known as the **fovea costalis superior** and **inferior**, articulate with the heads of the ribs which the vertebra supports.

The **foramen vertebrale** has a circular outline, and relatively is of small size.

The *pedicles* of the **arcus vertebrae** are short, and are attached much nearer to the upper than to the lower surface of the body. In correspondence with this we find that the **incisura vertebralis inferior** is very deep, and forms by far the greater part of the **foramen invertebrale** which it helps to enclose. This latter fact becomes obvious when two consecutive thoracic vertebrae are articulated with one another.

The *laminae* are short, strong and deep, and slope from above downwards and backwards in such a way that the laminae of one vertebra overlap those of the vertebra below like the tiles of a roof. In this way the **canalis vertebralis** is securely roofed over, and the thoracic portion of the spinal cord is protected from injury in the case of penetrating wounds in the back.

The **processus spinosus** is long and tapering, triangular in section, and directed downwards as well as backwards. The free end of the process is somewhat thickened, and lies on a level with the lower part of the body of the vertebra below. The downward direction and the overlapping of the spinous processes of the dorsal vertebrae must always be borne in mind when examining the back in the living subject.

Each **processus transversus** of a thoracic vertebra is thick, somewhat club-shaped, and directed backwards as well

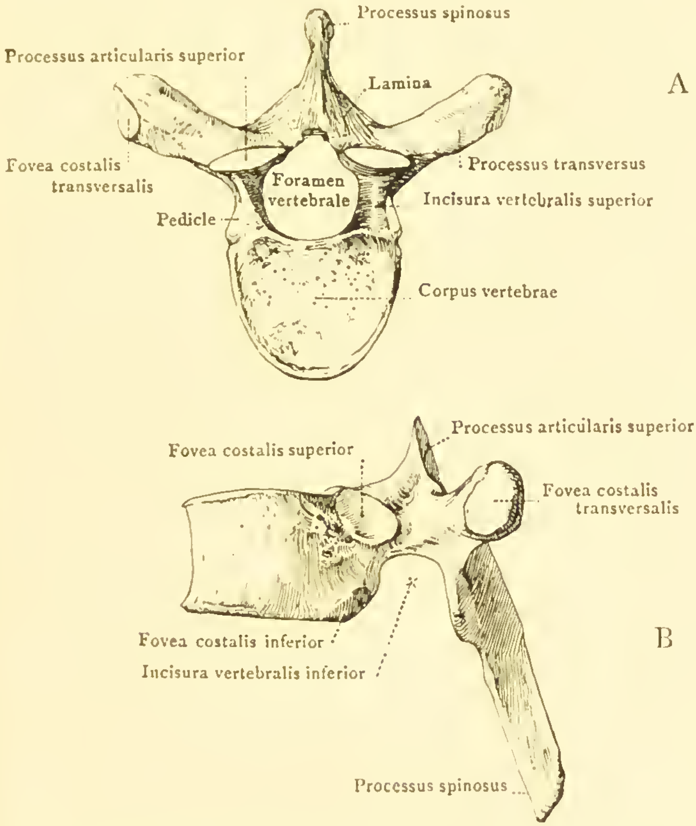

FIG. 8.—Thoracic vertebra; A, from above; B, from the left side.

as outwards. On its anterior aspect near its free end is an articular facet, the **fovea costalis transversalis**, for the tubercle of the corresponding rib.

The **processus articulares** are placed vertically, and the articular facets of the upper pair look backwards and slightly outwards; those of the lower pair forwards and slightly inwards.

If the student examine, in the complete skeleton, the way in which the ribs articulate with the thoracic vertebrae he will

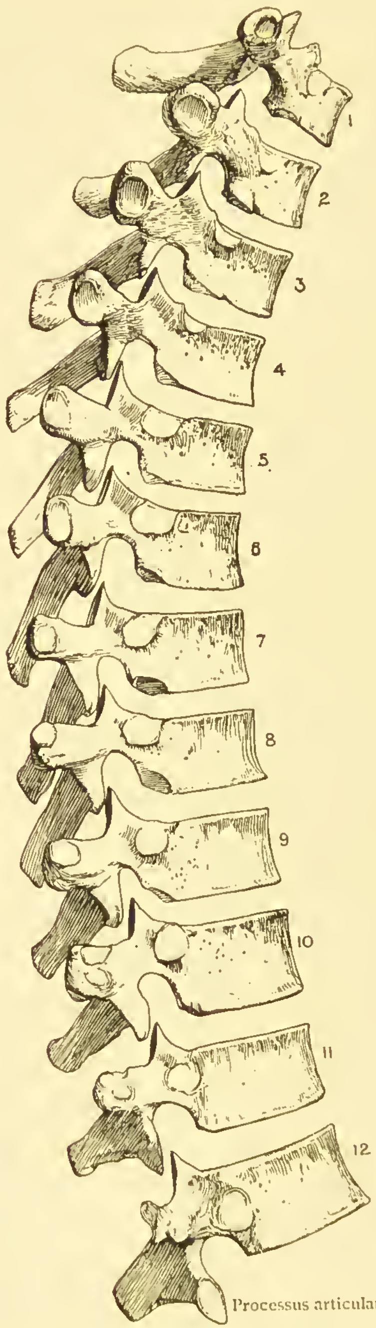

FIG. 9.—Thoracic subdivision of the columna vertebralis, seen from the right side. Note the arrangement of the articular facets for the ribs, and the disposition of the processus articulares.

readily satisfy himself that, except in the case of the first and the lower three ribs, each rib articulates by its tubercle with the facet on the processus transversus of the corresponding thoracic vertebra, and by its capitulum with the superior facet

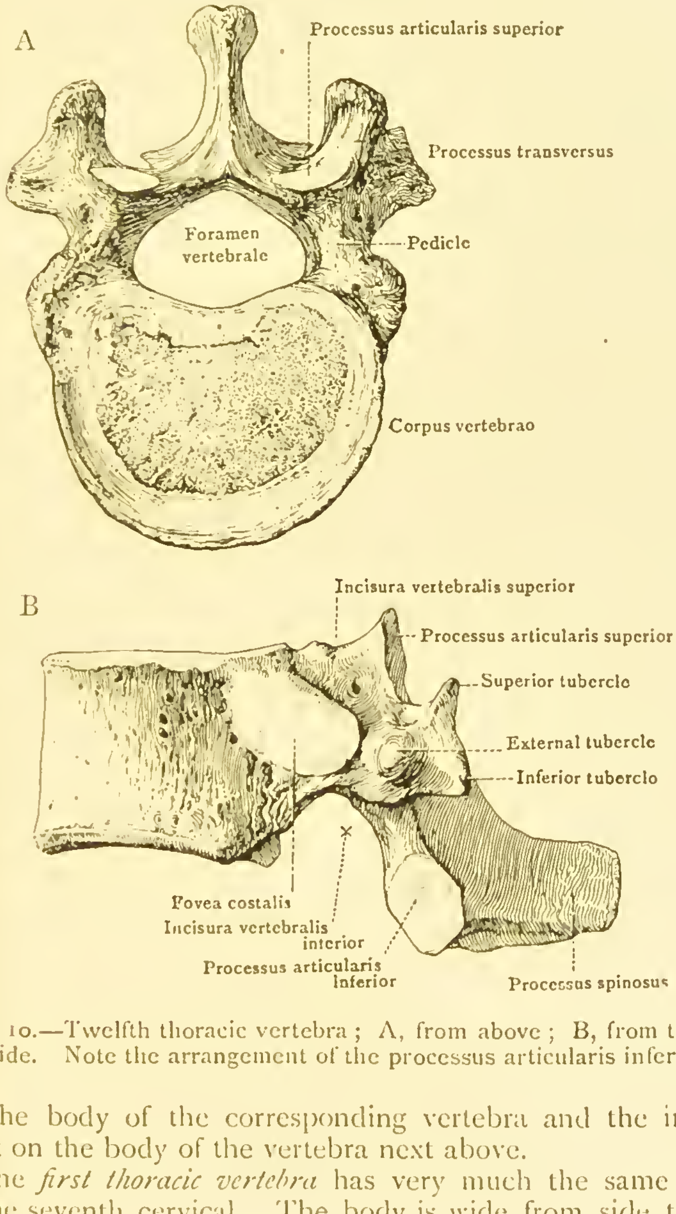

Fig. 10.—Twelfth thoracic vertebra; A, from above; B, from the left side. Note the arrangement of the processus articularis inferior.

on the body of the corresponding vertebra and the inferior facet on the body of the vertebra next above.

The *first thoracic vertebra* has very much the same shape as the seventh cervical. The body is wide from side to side and its upper surface has its lateral borders raised to form upwardly projecting ridges as in the cervical vertebrae. The fovea costalis superior is of large size, and forms with the adjacent intervertebral disc the whole of the socket for the capitulum of the first rib. The processus spinosus is relatively short, and is directed almost horizontally backwards, resembling that of the seventh cervical vertebra; like the latter it can readily be felt in the living subject.

The *eleventh* and *twelfth thoracic vertebrae* are characterized, and easily distinguished from the vertebrae higher up, by the absence of articular facets on their transverse processes. In their large size, and in the somewhat kidney-shaped outline of their bodies, they resemble the upper lumbar vertebrae, but the presence of costal facets for the heads of the ribs renders them easily distinguishable from the latter. In both the eleventh and the twelfth thoracic vertebrae, a single costal facet on each side is present; and it will be observed that it lies far back, and mainly on the pedicle of the vertebra. The processus transversi are of small size, and of irregular shape; and those of the twelfth thoracic vertebra usually end in three small tubercles, named superior, inferior, and external. Sometimes indications of these tubercles may also be seen on the transverse processes of the eleventh.

In spite of their general resemblance, an examination of their inferior articular processes will usually suffice to enable us to distinguish the eleventh from the twelfth thoracic vertebra. In the twelfth, the inferior articular facets look outwards, and not forwards as in the eleventh, and the other thoracic vertebrae. Thus in order to distinguish the eleventh from the twelfth thoracic vertebra it is usually necessary to compare only their inferior articular facets.

It is often possible to identify the *tenth thoracic vertebra* by its general shape, and by the fact that although the fovea costalis superior is well marked on each side of the body, the fovea costalis inferior is not represented.

VERTEBRAE LUMBALES.

The **vertebrae lumbales** are five in number, and are easily to be distinguished by their large size, and by the absence of costal facets, and of foramina in their transverse processes.

The large massive *bodies* are distinctly wider from side to side than from before backwards, and have a kidney-shaped outline.

The *pedicles* are short and massive, directed horizontally backwards, and attached to the bodies at a slightly lower level than those in the thoracic region.

The surfaces of the *laminae* are vertical, and do not overlap as in the thoracic region, and when the columna vertebralis is

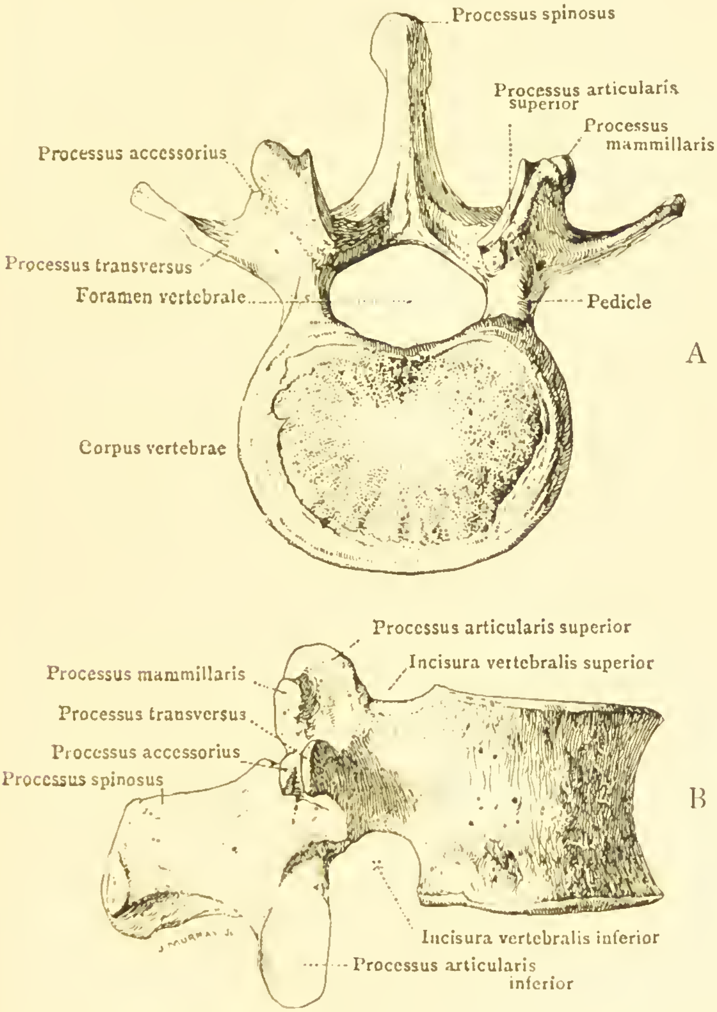

FIG. 11.—Lumbar vertebra; A, from above; B, from the right side.

viewed from behind it will be noticed that in the lower lumbar region marked intervals exist between the laminae of adjacent vertebrae. This arrangement of the parts is taken advantage of by physicians and surgeons, as it enables an instrument to be passed into the lumbar portion of the canalis vertebralis when it is desired to draw off fluid, or to introduce drugs. The student will notice that the interval is greatest between the laminae of the fourth and fifth lumbar vertebrae.

The **processus spinosi** of the lumbar vertebrae are laterally compressed, quadrilateral plates of bone, with thickened posterior borders.

The **processus transversi** are slender, flattened from before backwards, and directed outwards and slightly upwards and backwards.

The **processus articulares** are very strong, and interlock much more securely than in the other subdivisions of the columna vertebralis. If two of the vertebrae lumbales be carefully articulated, it will be noticed that the processus articulares superiores of the lower vertebra lie to the outside of the processus articulares inferiores of the upper, and that the upper vertebra is embraced by the lower one in such a way that lateral displacement or dislocation is impossible. The articular facets on the superior processes look inwards; those on the inferior processes outwards.

The somewhat elongated tubercle, which lies on the posterior edge of the curved plate formed by the superior articular process, is called the **processus mammillaris**, and the less conspicuous tubercle on the posterior aspect of the base of the processus transversus is spoken of as the **processus accessorius**.

The **foramen vertebrale** is larger from side to side than in the thoracic region; it transmits, in the case of the lower lumbar vertebrae, the great lumbar and sacral nerves which come from the lower part of the spinal cord. The spinal cord usually does not occupy the canalis vertebralis below the level of the upper edge of the second lumbar vertebra, as it ends at this level.

The *fifth lumbar vertebra* may be distinguished by its wedge-shaped body, which is considerably deeper in front than behind, and by its massive somewhat conical transverse processes. Its foramen is distinctly triangular in outline, and its inferior articular processes, by which it is firmly jointed to the os sacrum, are wider apart than its superior processes. Its spine viewed from the side is triangular rather than quadrilateral, as in the other lumbar vertebrae. In the articulated skeleton the student will notice that the lumbar portion of the columna vertebralis forms a curve which is convex forwards. This curve is mainly due to the formation of the intervertebral discs which unite the bodies of the vertebrae. Except in the case of the fifth, and to a far less extent in the fourth (and very rarely in the third), the bodies of the vertebrae lumbales are usually not deeper in front than behind.

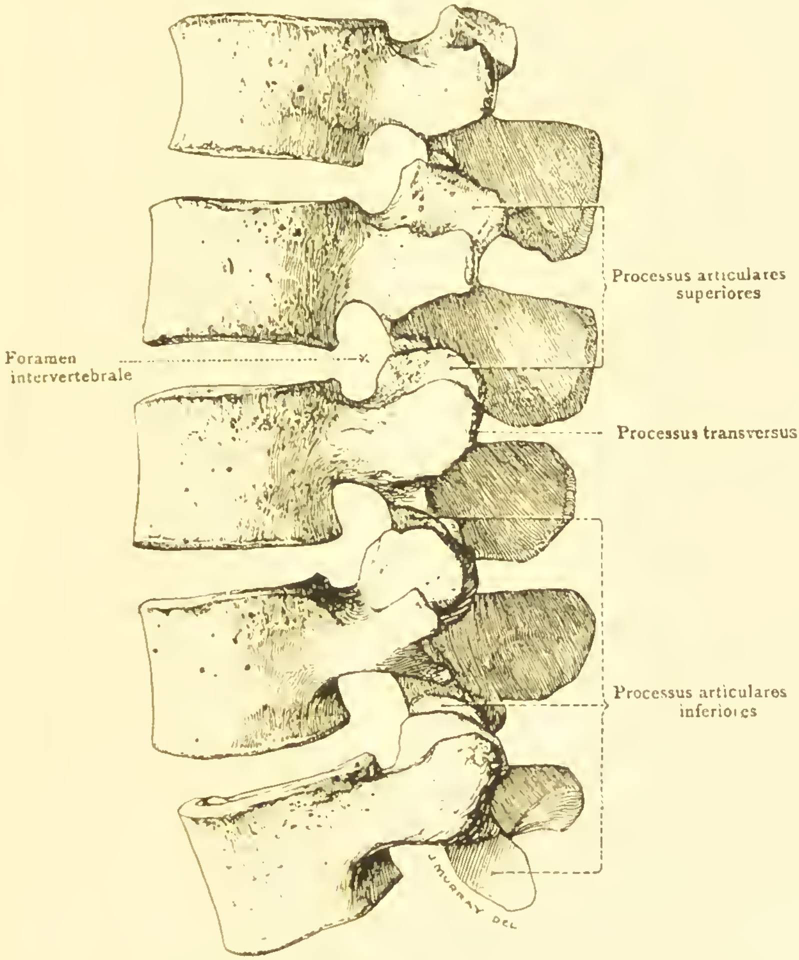

Fig. 12.—Lumbar subdivision of the columna vertebralis. Note the interlocking of the processus articulares.

OS SACRUM.

The **os sacrum** is the somewhat triangular mass of bone formed by the fusion of the five **vertebrae sacrales**. In the child the composite nature of the bone is quite obvious, and even in the adult there are marks which enable us to recognize the lines along which union of the vertebrae has taken place. The sacrum is wide above at its base, which is directed upwards and forwards; narrow below at the apex, which is

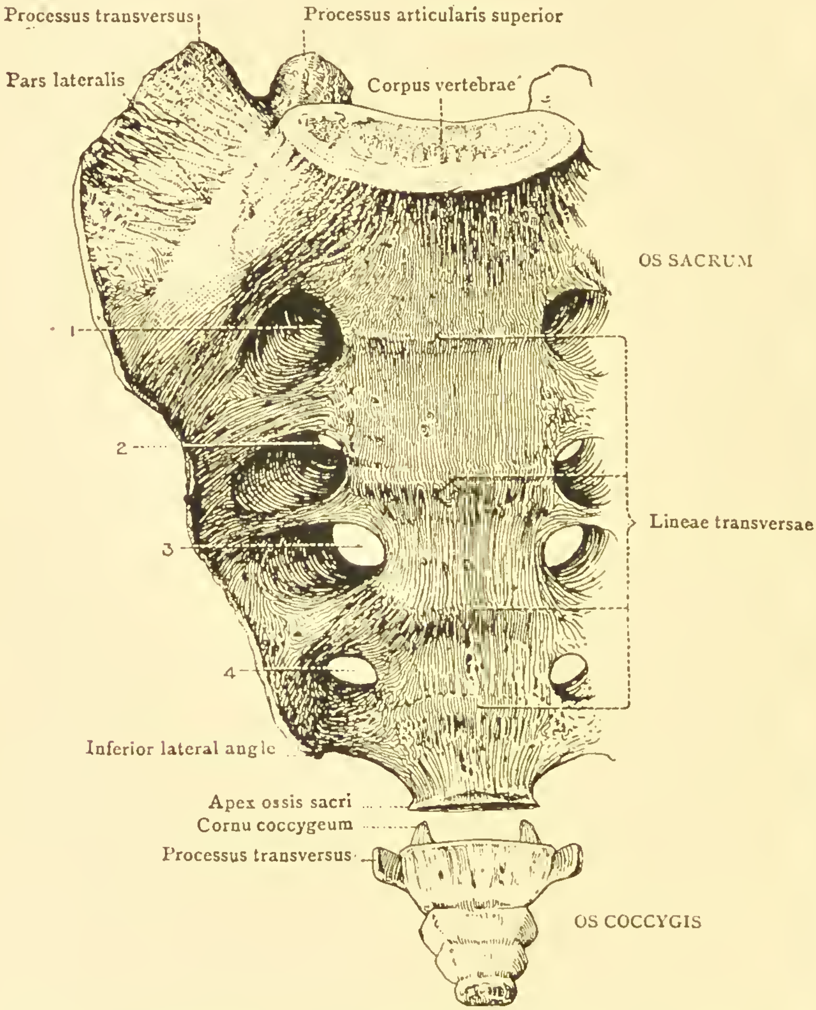

FIG. 13.—Os sacrum and os coccygis: facies pelvina. The foramina sacralia anteriora are indicated by the numbers 1–4.

directed downwards and backwards. The anterior surface, or **facies pelvina,** forms the posterior wall of the pelvic cavity. It is smooth and concave, both from above downwards and from side to side. In the middle line of the anterior surface we recognize the bodies of the sacral vertebrae, which diminish in size as they are traced downwards. In young subjects, the bodies of the sacral vertebrae are clearly marked off from one another, and are but loosely connected; in the adult they are

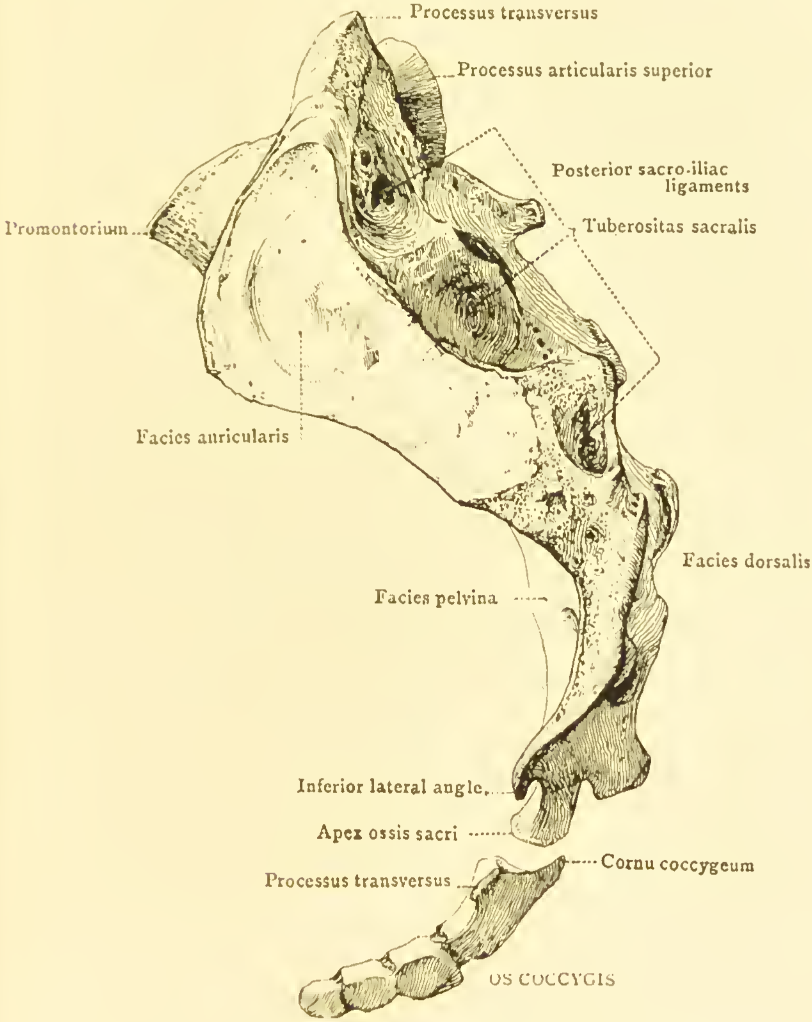

FIG. 14.—Os sacrum and os coccygis from the left side.

firmly fused together, but usually four faintly marked lines, or ridges, indicate the planes along which union has taken place. These lines, the **lineae transversae**, end on each side in four well-defined **foramina sacralia anteriora**, which serve for the passage of the anterior divisions of the sacral nerves. Externally the foramina are eontinued into smooth shallow grooves, in whieh the nerves lie immediately after they have issued from the foramina. The part of the bone whieh lies to the outside of the foramina is spoken of as the **pars lateralis**, or *lateral mass*; anteriorly it is smooth and eontinuous with the bodies of the saeral vertebrae in the intervals between the anterior saeral foramina.

If the bone is viewed from its outer aspeet it will be seen that the upper portion of the pars lateralis bears a well-marked artieular faeet, the **facies auricularis**, by means of which the saerum artieulates with the os eoxae, or innominate bone. Behind the faeies aurieularis are two or three rough pits, or depressions, whieh give attaehment to the extremely powerful posterior saero-iliae ligament, one of the strongest of the ligamentous eonnexions between the os saerum and the innominate bone. This rough area is spoken of as the **tuberositas sacralis**. Below the level of the aurieular faeet the outer aspect of the pars lateralis becomes gradually redueed in thiekness, and forms a rough eurved edge, to which the great saero-seiatic ligament is attaehed. The lowest limit of this edge forms a prominenee ealled the *inferior lateral angle* of the saerum, and lies just above and to the outer side of the point where the anterior division of the fifth saeral nerve turns forwards. In some eases this inferior lateral angle is fused to the transverse proeess of the first eoccygeal vertebra, and then the saerum exhibits five foramina on each side instead of four. This eondition is so frequently present that the student should bear it in mind, and be prepared to reeognize its significanee.

In marked eontrast with the eoneave and smooth faeies pelvina is the **facies dorsalis.** The latter, convex from above downwards and slightly so from side to side, is rough and irregular. In the middle line may be recognized a ridge, the **crista sacralis media**, or in some eases a series of tubercles whieh represent the more or less fused spines of the saeral vertebrae. Immediately external to this ridge is a sloping area formed by the fused *laminae*. Further out still, we have the **foramina sacralia posteriora** which transmit the posterior divisions of the sacral nerves, and lie opposite to the anterior foramina. In many eases the student will reeognize that at the inner margin of eaeh foramen there is a little elevation which represents the fused articular processes of two saeral vertebrae. These are spoken of as the **cristae sacrales articulares.** The superior articular processes of the first sacral vertebrae and the inferior processes of the last are free and well marked. The former are wide apart and embrace between them the inferior processes of the last lumbar vertebrae, the latter lie much

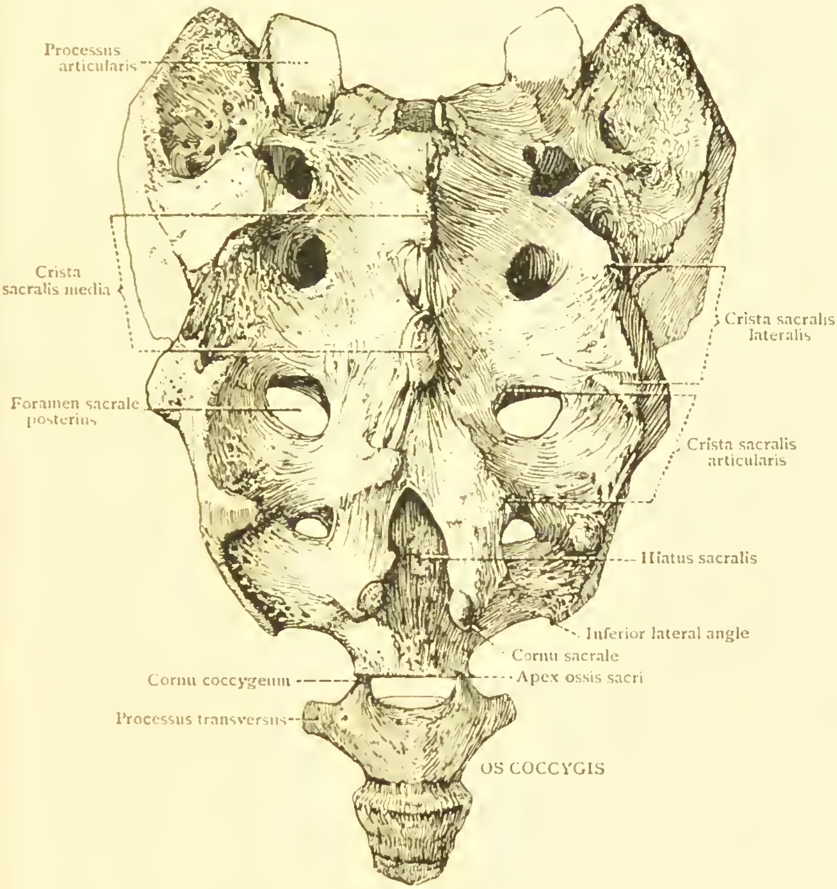

FIG. 15.—Os sacrum and os coccygis : facies dorsalis.

closer together and are called the **cornua sacralia.** They are connected by ligaments to the cornua of the coccyx. To the outer side of the posterior sacral foramina are a series of indistinct elevations, the **cristae sacrales laterales,** which represent the transverse processes of the sacral vertebrae. Usually the transverse processes of the first sacral vertebra are fairly easily identified.

The sacrum is traversed by a canal, the **canalis sacralis**, which is the continuation of the canalis vertebralis, and opens out at a variable level on the dorsal aspect of the bone. The opening, termed the **hiatus sacralis**, lies between the cornua sacralia and below the lower end of the crista sacralis media. In some bones the sacral canal, which transmits the sacral nerves, is very short ; in others it reaches almost to the lower end of the sacrum.

The lower end of the bone, termed the **apex ossis sacri**, is formed by a small oval surface which is the under aspect of the body of the fifth sacral vertebra. This surface is connected

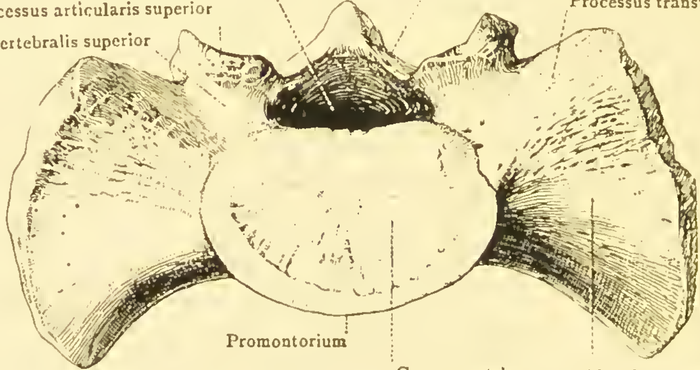

FIG. 16.—Os sacrum from above : basis ossis sacri.

to the body of the first coccygeal vertebra by a mass of fibro-cartilage.

An examination of the upper surface of the sacrum, or **basis ossis sacri**, shows that the first sacral vertebra has a large body, the upper surface of which is oval in outline. Behind this is the upper opening of the **canalis sacralis**, or sacral canal, triangular in form and bounded by the laminae, pedicles, and body of the first sacral vertebra. The vertically placed processus articulares are wide apart, and possess articular facets which look backwards and inwards. On each side of the body of the first sacral vertebra we recognize the upper aspect of the pars lateralis, and behind it, in most cases, the outline of the transverse process of the vertebra may be distinguished. The term *ala of the os sacrum* is often applied to the somewhat triangular upper surface of the lateral mass, which lies in front of the part of the bone representing the transverse process.

In the articulated columna vertebralis, the anterior edge of the body of the first sacral vertebra will be seen to lie at the prominent angle where the lumbar part of the vertebral column joins the sacral subdivision. This angle is called the **promontorium**, or sacral promontory, and lies at the posterior edge of the entrance, or **apertura superior**, of the pelvic cavity.

When a number of skeletons are compared it will be seen that the os sacrum is a very variable bone, being in some cases shorter and broader than usual, in others longer and narrower. The curvature of the os sacrum is also liable to considerable variation, in some bones the amount of curvature is slight and uniform; in others the curvature is strongly marked, or the bone appears as if bent sharply on itself near its lower end. As a general rule it will be found that in the male skeleton the sacrum is longer and relatively narrower than in the female, and that the curvature is more uniform. The os sacrum in the female is often but slightly curved in its upper part, and rather suddenly bent forwards near its lower end.

Attention has already been called to the fact that the first coccygeal vertebra is sometimes fused to the lower end of the os sacrum. Far less often the last lumbar vertebra is completely, or partially united to the sacrum. The sacrum, as a result of either of these conditions, may be composed of six vertebrae. Recent research supports the view that in a majority of the cases in which a vertebra appears to be partially fused to the upper end of the sacrum, we are dealing with a setting free of a sacral vertebra, and not with the absorption of a lumbar vertebra into the os sacrum.

OS COCCYGIS.

The *coccygeal*, or *tail vertebrae*, are vestigeal structures and liable to much variation. Usually they are four in number, but sometimes their number is increased to five, or reduced to three. Fusion of these **vertebrae coccygeae** normally occurs in the adult. Very often they are united to form a single bone, called the **os coccygis**; or the lower three pieces may fuse together, the first remaining separate, or becoming joined to the os sacrum. The *first coccygeal vertebra* possesses (1) a body, slightly smaller in size than that of the last sacral vertebra, and united to it by fibro-cartilage, (2) a pair of laterally projecting proccssus transversi, and (3) a pair of rudimentary processus articulares called **cornua coccygea.** These latter are united by ligaments to the cornua sacralia. The *lower coccygeal vertebrae* are usually represented by small bony nodules corresponding in number with the vestigeal vertebrae.

THE COLUMNA VERTEBRALIS AS A WHOLE.

Having completed a survey of its segments, the student should supplement his knowledge by a further study of the columna vertebralis as a whole, as it is displayed in an articulated skeleton, or in a mesial section of such a skeleton (see fig. 1).

A glance at the articulated skeleton shows that the axis formed by the columna vertebralis is not straight, but exhibits four well-marked curves. In the cervical region the column is convex forwards, in the thoracic region concave forwards, in the lumbar region convex forwards, and in the sacro-coccygeal region concave forwards. Further, it is evident that the concavity in the thoracic and sacro-coccygeal regions gives increased capacity to the thoracic and pelvic cavities; the forward curve in the neck and lumbar regions is compensatory, and makes the axis of the trunk approximately vertical when the subject stands erect. The dorsal and sacro-coccygeal curves are termed 'primary', and are present in the early stages of development. They are due to the shape of the bodies of the vertebrae forming these regions of the spinal column. The cervical and lumbar curves are termed 'compensatory', and are only developed after birth. They are essentially due to the form of the intervertebral substance, although, as we have seen, the shape of the bodies of the lower lumbar vertebrae to a very slight extent may contribute to the formation of the forward convexity in this region. The remarkable wedge-shaped form of the body of the last lumbar vertebra is largely responsible for the backward tilt of the sacrum, and for the marked angle which occurs at the junction of the lumbar and sacro-coccygeal curves in the region of the promontorium. The transition of the cervical into the thoracic, and of the thoracic into the lumbar curves, is very gradual.

When the column is viewed from in front, the gradual increase in size and strength of the supporting axis, formed by the bodies of the vertebrae, from the second cervical vertebra above to the last lumbar below, is very obvious. The intervertebral discs are also thicker in the lower part of the vertebral column.

It is important to notice the disposition of the processus spinosi of the different regions, in the articulated vertebral column. Many of these can be felt in the living subject, and form important landmarks, by means of which deep structures may be mapped out on the surface of the body. The tips of the spines do not lie in a straight, but rather in an irregular line; and frequently it will be noticed that the vertebral column is, as a whole, slightly curved to the right side in the thoracic region.

We have seen that the spine of the atlas is represented by a small tubercle, that the spine of the second vertebra is strong and massive, and that the spines of the third, fourth, fifth, and sixth are bifid and small. Usually none of these except the sixth, which projects more than the others, can be felt in the living subject. The spine of the seventh cervical projects far backwards, and is usually an easily recognizable landmark during life.

The spines of the first and second thoracic vertebrae also project almost horizontally backwards, and are often readily recognizable in the living subject. In the middle thoracic region the spines project downwards rather than backwards, an arrangement which should always be remembered when examining the back in the living subject. The level of any one of these thoracic spines is considerably lower than the level of the body of the corresponding vertebra, or of the foramen intervertebrale for the corresponding spinal nerve. An examination of the thoracic region will explain why the thoracic processus spinosi become more projecting, and therefore more readily recognizable, in the living subject when the trunk as a whole is bent forwards.

In the lower thoracic region, and in the lumbar subdivision of the vertebral column, the spines project nearly horizontally and lie more nearly on the same level with the foramina for the exit of the spinal nerves.

In the sacral region the spines form a ridge, or series of tubercles, which ends at the hiatus sacralis, where the sacral canal opens out inferiorly.

On each side of the row of spinous processes a longitudinally directed groove will be noticed, the floor of which is formed by the laminae of the vertebrae, as they roof in the canalis vertebralis for the spinal cord. In the thoracic region, the roof of the canal is very perfectly formed, owing to the overlapping of the laminae, but in the lower lumbar region gaps occur corresponding to the intervals between the laminae of the lumbar vertebrae. Usually the widest gap is present, as we have seen, between the laminae of the fourth and fifth lumbar vertebrae (page 24).

It is well that the student should familiarize himself with the appearances presented by the processus transversi as viewed from behind. He will notice that the width of the vertebrae, as measured by the interval between the tips of these processes, varies strikingly in the different regions of the spine, and he will realize that a knowledge of the relative positions of the processes is often essential for the interpretation of X-ray photographs which include portions of the vertebral column. The transverse processes of the atlas are wide apart; those of the other cervical vertebrae lie nearer to the mesial plane. The width between the distal ends of the processus transversi of the first thoracic vertebra is relatively great, and approximately equal to the width of the atlas. In the vertebrae lower down, the width diminishes gradually until the twelfth thoracic vertebra is reached. In the lumbar region a great increase takes place, which usually reaches a maximum in the third or fourth lumbar vertebra. The greatest width between the processus transversi is to be met with in the first sacral vertebra.

THE THORAX.

The cage-like skeleton of the *chest*, or **thorax**, is formed by the thoracic vertebrae, the sternum or breast-bone, and by the ribs and costal cartilages which curve round on each side from the vertebral column towards the sternum.

THE RIBS.

Before examining the individual ribs, or **costae**, their disposition in the articulated skeleton should be studied. Each rib will be found to be articulated posteriorly with the thoracic part of the vertebral column, and to be joined in front by a strip of cartilage called the **cartilago costalis**, or costal cartilage. The cartilagines costales of the upper seven ribs reach, and are firmly connected to, the lateral border of the sternum, but those of the lower five do not extend so far forwards. The upper seven ribs are named **costae verae**, or true ribs; and the lower five **costae spuriae**, or false ribs.

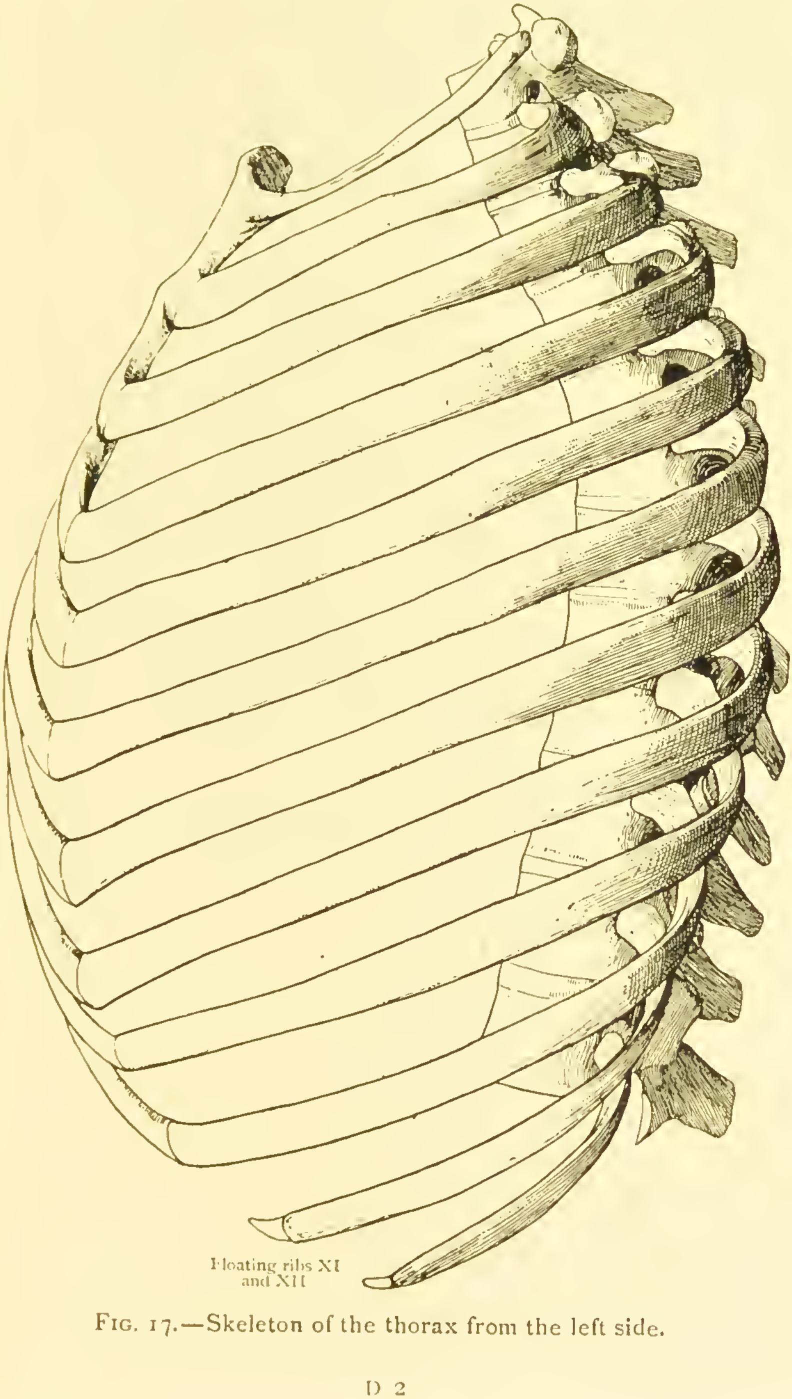

FIG. 17.—Skeleton of the thorax from the left side.

It will readily be noticed that although the costal cartilages of the eighth, ninth, and tenth ribs do not reach the sternum, they are connected to one another, and to the cartilage of the seventh rib, by ligaments; and further, that the cartilages of the eleventh and twelfth ribs are relatively very short, and end in the muscles of the abdominal wall without being connected to the ribs above. These latter are often called *floating ribs*, on account of their loose attachment to other parts of the skeleton.

Thus, in the human subject we have:—

seven pairs of costae verae, or true ribs;
five pairs of costae spuriae, or false ribs.

Of the latter, the lower two pairs, the eleventh and twelfth, form the floating ribs.

The student should note that each rib as a whole slopes downwards and forwards, so that its posterior end lies on a distinctly higher level than its anterior. Also, it will be seen that the ribs increase in length from the first to the seventh, or eighth, and then diminish in length until the twelfth is reached.

A separated rib from near the middle of the series should be carefully examined.

The anterior, or sternal, extremity is readily identified, as it is hollowed out to form a pit, into which the cartilago costalis is received.

The posterior, or vertebral, end is slightly expanded, and forms the **capitulum costae**, or head, which articulates with the bodies of two vertebrae. If the capitulum is viewed closely, it is usually possible to recognize upon it two sloping facets, separated by a slightly marked horizontal ridge. The lower of these facets articulates with the body of the thoracic vertebra having the same number as the rib; the upper facet, with the vertebra next above. The ridge is connected by fibrous tissue to the intervening intervertebral disc.

The part of the rib which supports the capitulum is spoken of as the **collum costae**, or rib neck. It is compressed from before backwards, and rough on its posterior surface, for the attachment of ligamentous fibres, which connect it to the processus transversus of the vertebra. The upper border of the neck forms a sharp edge for the attachment of a ligament connecting the rib to the transverse process of the vertebra above.

Where the neck joins the shaft or body of the rib, there is a small elevation, known as the **tuberculum costae**, situated on the convex aspect of the bone. This tuberculum is usually subdivided into an inner and lower portion bearing an articular facet, and an outer and upper non-articular part. The former articulates with the facet on the processus transversus of the corresponding vertebra, and the latter gives attachment to a strong ligament (posterior costo-transverse), which connects it to the tip of the same processus transversus.

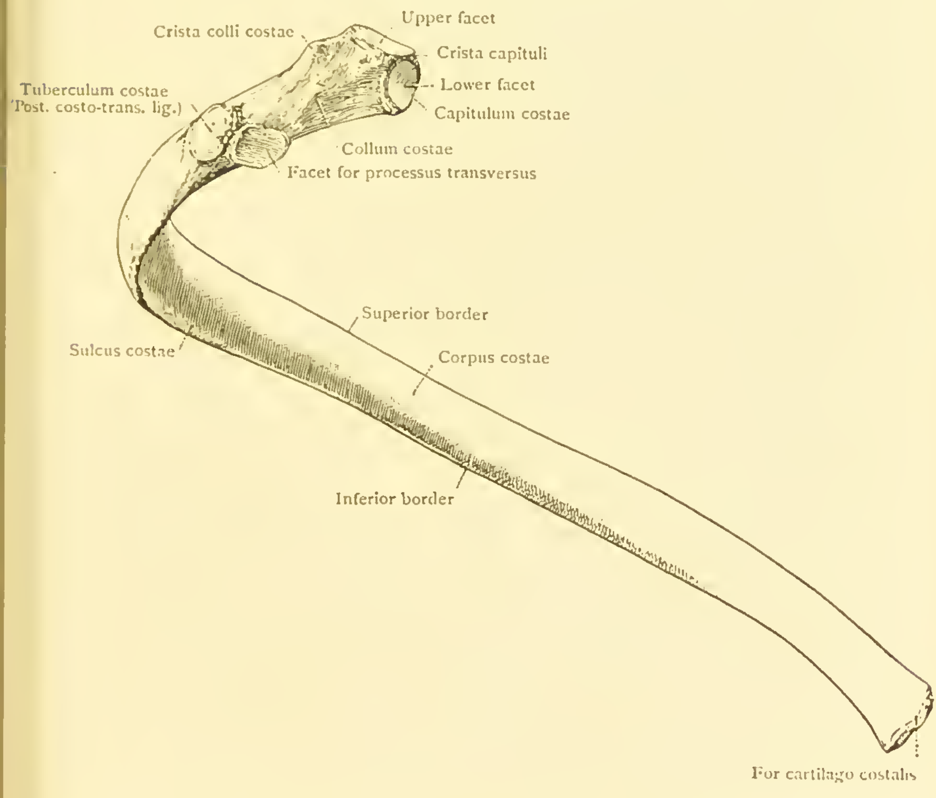

FIG. 18.—Sixth rib from the posterior and inner aspect.

The part of the rib beyond the tuberculum is called the body, or **corpus costae**, and possesses an upper and a lower border, a deep and a superficial surface. It will be noted that the curvature of the rib is not uniform, but is most pronounced near the posterior end, a short distance to the outer side of the tubercle. In this position the rib appears as if sharply bent upon itself, and the term angle, or **angulus costae**, is employed to denote the bend. On the superficial aspect of the rib, a rough line indicates the position of the angulus, and the student should note that in the articulated skeleton this line on each rib runs a vertical course, and corresponds to the part of the rib which lies most posteriorly. The interval between the spines of the vertebrae and the angles of the ribs is occupied in the living subject by the great erector spinae muscle, and so the rough line on the costal angle indicates the outer border of this important muscle mass. The ribs are not merely curved, but they show a slight twist in their long axes. As a result, the superficial surface looks upwards as well as forwards near the anterior extremity of the rib. The greater part of the outer, or super-

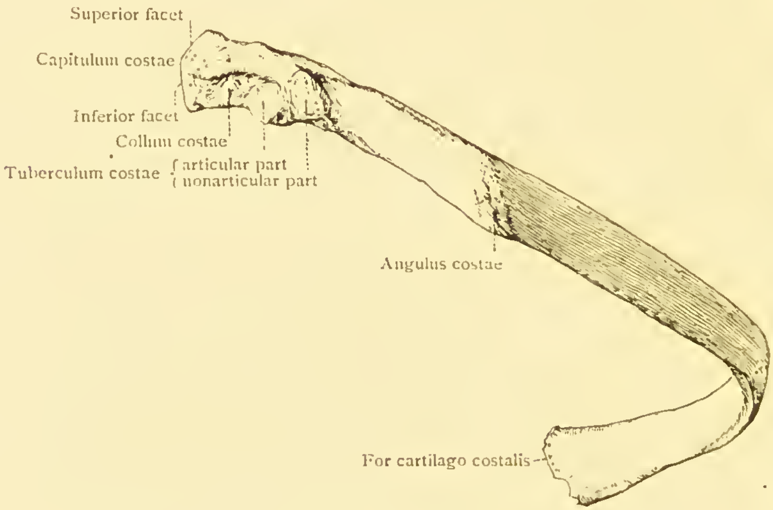

FIG. 19.—Ninth rib from behind.

ficial aspect of the rib is covered by, or gives attachment to, the powerful muscles of the arm and of the abdominal wall; the deep surface is clothed by the pleural membrane which lines the cavity occupied by the lung. On the deep surface, near the lower border of the rib, a groove called the **sulcus costae** is to be noted. This groove passes obliquely over the lower border of the rib as it is traced forwards, and, in the living subject, lodges the intercostal vessels and nerve. It is important to remember that posteriorly the vessels and nerves lie protected by the rib in the sulcus costae, but that, as they come forwards, they lie below the rib in the intercostal space. The bodies of the ribs give attachment to the intercostal muscles, which fill up the intercostal spaces.

The upper ribs are more curved than the lower (compare figs. 20 and 21); and the first and second ribs are easily distinguished from all the others.

THE FIRST RIB.

The *first ribs* bound the superior opening of the thorax and are very short, flattened from above downwards, and much

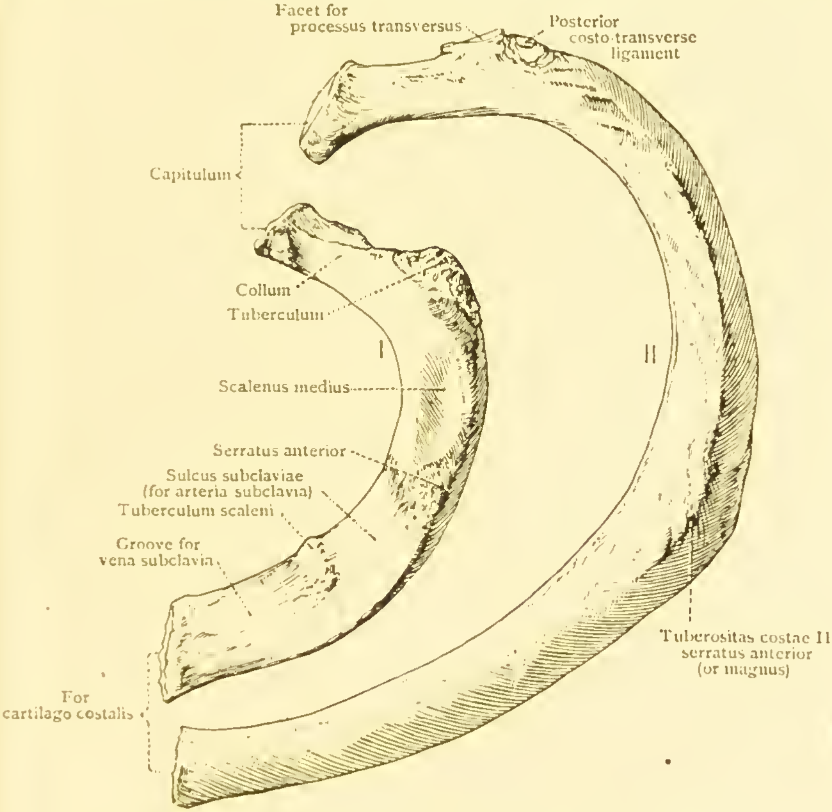

FIG. 20.—First and second ribs of the left side from above.

curved in their long axes. Each possesses a wide upper surface looking upwards and forwards, and a lower surface looking downwards and backwards; the borders which limit these surfaces are named inner and outer, and not upper and lower, as in the other ribs. The first rib is placed very obliquely, and hence, in spite of its shortness, the anterior end lies on a considerably lower plane than the posterior. The capitulum is well marked, and bears a single articular facet for the body of the first thoracic vertebra. The neck is long, and more slender and cylindrical than in the other ribs. The tuberculum is prominent, and situated in the outer border, in the region of the angulus.

If the finger be passed along the inner concave border of the first rib, a slight elevation will usually be detected on this border, somewhat nearer to the anterior than to the posterior end of the bone. This is known as the **tuberculum scaleni**, and in most cases it is continued as a somewhat rough mark on to the inner part of the upper surface of the bone.

Behind the tuberculum scaleni there is a smooth area, or groove, known as the **sulcus subclaviae**, over which the great subclavian artery lies, as it crosses the first rib to enter the armpit. The groove is even more intimately related to the lowest of the great nerve-trunks which pass from the root of the neck into the upper limb. The student will appreciate the importance of the tuberculum scaleni when it is mentioned that it together with the tendon of the scalenus anterior muscle, which is inserted into it, form the guide made use of by the surgeon in exposing the third stage of the subclavian artery.

The great vein of the upper limb, or subclavian vein, lies on the smooth area in front of the tuberculum scaleni, as it passes upwards and inwards into the root of the neck. In most cases, rough marks for the attachment of the following muscles may also be seen on the first rib:—serratus anterior (magnus), rough mark on the outer border; scalenus medius, rough area behind the sulcus subclaviae; and subclavius, rough impression on upper surface near its junction with the costal cartilage (see figs. 20 and 23). The under surface of the rib exhibits no sulcus costae and is covered by pleura.

THE SECOND RIB.

The *second rib* resembles the first in being strongly curved, but it is much longer. It is always easily recognized by a rough mark, the **tuberositas costae**, which it bears near the middle of its upper and outer aspect for a part of the origin of the serratus anterior. The angulus lies just to the outside of the tuberculum. The head possesses two articular facets, the upper for the body of the first, and the lower for that of the second thoracic vertebra. The sulcus costae is present but it is faintly marked.

THE ELEVENTH AND TWELFTH RIBS.

The *eleventh* and *twelfth ribs* are very variable. They are usually short, slender, tapering, and pointed towards their anterior ends. They are uniformly and but slightly curved,

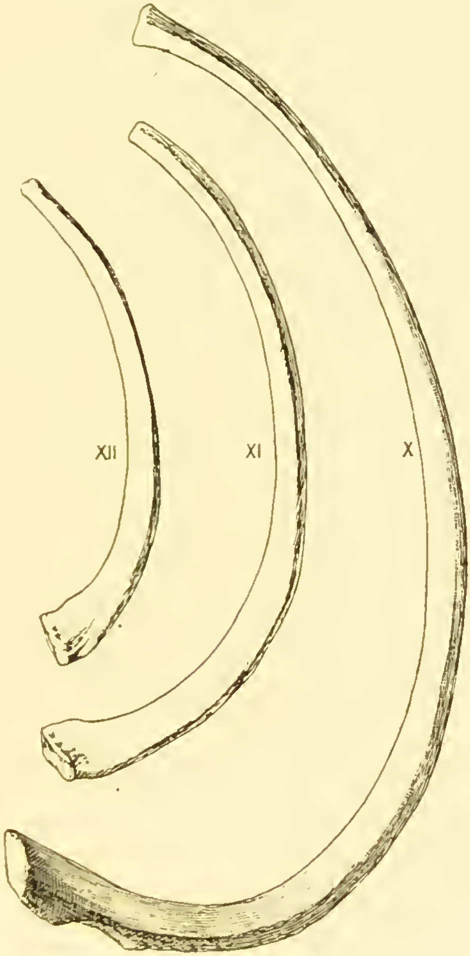

Fig. 21.—Lower three ribs of the right side from above.

the angulus being absent. The capitulum has a single articular facet for the body of the corresponding thoracic vertebra, and there is no distinct neck. The tuberculum is absent, or sometimes represented by a rough mark in the case of the eleventh rib; the sulcus costae is absent in the twelfth rib, and but faintly marked in the eleventh.

THE TENTH RIB.

The *tenth rib* may often be recognized by the fact that the capitulum carries a single articular facet, and the line indicating the outer edge of the erector spinae muscle lies far outside the tuberculum. In other ways this rib resembles those higher up in the series.

THE STERNUM.

The **sternum**, or *breast-bone*, occupies the middle line of the chest cavity in front, and is supported on each side by the upper seven costal arches. It is composed of three portions placed one above the other, and named in order from above downwards—**manubrium sterni**, **corpus sterni**, and **processus xiphoideus**. The long axis of the sternum slopes downwards and forwards, its superior end lying on a plane posterior to that of its inferior extremity. It will be noticed that in most cases the manubrium sterni meets the corpus sterni at an angle, the **angulus sterni**, which may readily be felt in the living subject as a ridge crossing the middle line on the front of the chest, at the level of the second costal cartilage. This ridge lies superficial to the cartilaginous plate uniting the manubrium and corpus sterni, and is a useful landmark in determining the position of deeper structures.

The **manubrium** is the widest and thickest part of the sternum, and in shape it somewhat resembles an irregular hexagon; it is widest where it articulates with the costal cartilages of the first ribs, and it narrows inferiorly where it joins the corpus sterni. The upper border of the manubrium shows a median notch, the **incisura jugularis**, or interclavicular notch, which is easily identified in the living at the root of the neck. On each side of this median notch there is an articular depression, called the **incisura clavicularis**, for the thick inner end of the clavicle. These articular facets lie on the thickest part of the bone.

Following the circumference of the manubrium, we recognize below the incisura clavicularis a rough pit for the reception of the first costal cartilage; lower still, the bone rapidly narrows, and the outer edge of the manubrium is thin where it forms the inner boundary of the first intercostal space. The narrowest part of the manubrium lies at the level of the upper part of the second costal cartilage, where the outer border of the bone forms the upper portion of the fossa for this cartilage.

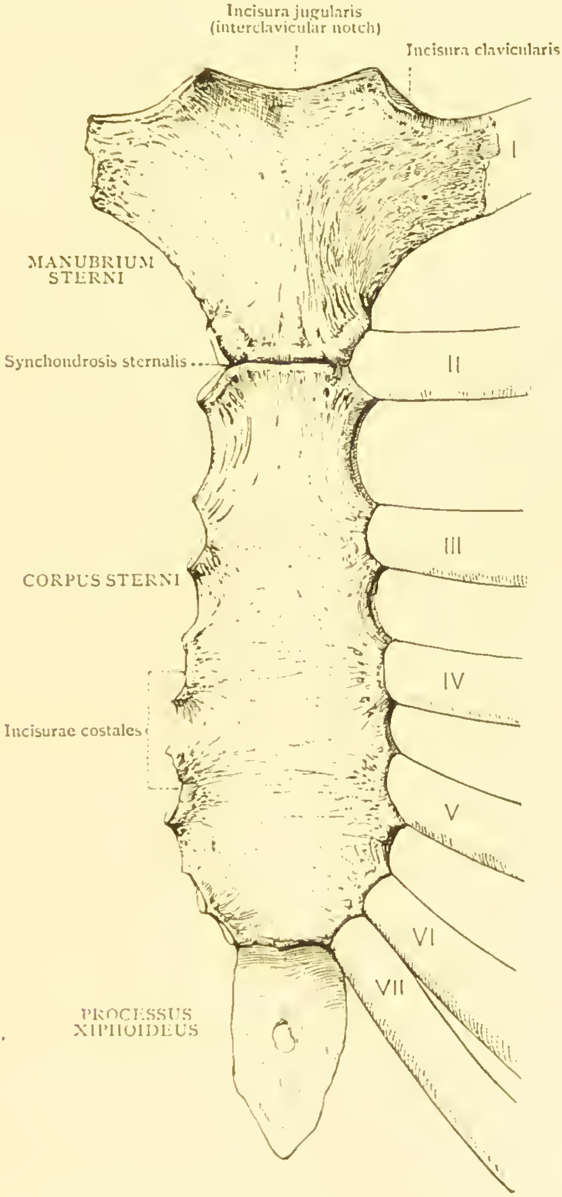

FIG. 22.—The sternum from in front.

The lower border of the manubrium is thick, and is united by a plate of fibro-cartilage with the upper end of the corpus sterni. Somewhat rarely, in old people, this cartilage becomes ossified, and then the upper two segments of the sternum are completely fused together.

The anterior aspect of the manubrium sterni, in its lower part, is hollowed out on each side of the middle line, where it gives origin to a portion of the pectoralis major muscle. Higher up, and nearer to the middle line, the rough anterior surface of the manubrium affords origin to the sternal head of the sterno-cleido-mastoideus muscle, and close to the incisura clavicularis it is rough for the attachment of the anterior sterno-clavicular ligaments.

The posterior surface of the manubrium is flat, or slightly concave, and gives origin to some fibres of the sterno-hyoideus and sterno-thyreoideus muscles. It looks into the thoracic cavity, and forms the anterior wall of its upper part.

The **corpus sterni** is the longest of the three subdivisions of the breast-bone, and articulates with the costal cartilages of all the true ribs except the first. It is narrow above at the level of the second costal cartilage where it joins the manubrium, and it gradually increases in width until the level of the fifth costal cartilage is reached; below this it becomes reduced rather rapidly in width. Its lower end supports the processus xiphoideus.

Each lateral border of the corpus sterni exhibits a series of articular pit-like depressions, or notches, the **incisurae costales**, for the costal cartilages of the second to the seventh ribs. The pit for the second costal cartilage is completed by the manubrium sterni, and that for the seventh by the processus xiphoideus. In the intervals between these pits the lateral border of the bone is in relationship to the intercostal spaces.

The anterior aspect of the corpus sterni is flat, or slightly concave from side to side, and gives origin to part of the pectoralis major muscle. It sometimes exhibits three, faintly marked, transverse lines connecting the third, fourth, and fifth incisurae costales of opposite sides, and indicating the lines of fusion between the four elements of which the corpus sterni is originally composed. In the young subject the separate segments which form the corpus sterni are united by cartilaginous plates which lie in the positions afterwards indicated by the faint transverse lines in the adult bone. In some cases a hole, or perforation, is found in the lower part of the corpus sterni of the adult. This results from incomplete ossification and fusion of the component parts. In the neighbourhood of each costal facet the anterior surface of the corpus sterni is rough for the attachment of ligamentous fibres.

The posterior aspect of the bone is slightly concave from side to side, and gives origin to the transversus thoracis, or triangularis sterni muscle. It lies in front of the heart and the anterior parts of the lungs.

The **processus xiphoideus**, or ensiform process, projects downwards below the corpus sterni, and is very variable in form and size. It is usually incompletely ossified, its lower part being mainly composed of cartilage. Frequently it is bifid at its lower end; or it is perforated by a foramen. To its lower extremity is attached the upper end of the linea alba of the abdominal wall, and from its posterior aspect a part of the diaphragm and of the transversus thoracis muscle take origin. The student will recognize that, as the anterior surface of the processus xiphoideus lies on a posterior plane to the anterior aspect of the corpus sterni, the processus xiphoideus in the living subject lies in the hollow below the main part of the sternum and in the interval between the seventh costal cartilages of opposite sides. This depression is termed the pit of the stomach.

THE THORAX AS A WHOLE.

Having completed a survey of its component parts the student is advised to again direct his attention to the thorax in the articulated skeleton, and to carefully examine the form of the chest cavity. He will notice the somewhat conical outline of the chest as viewed from in front, or behind; the small size of the upper opening, or **apertura thoracis superior**, and the great width of the **apertura thoracis inferior.**

The apertura superior, often called the *thoracic inlet*, is narrow from before backwards, having an antero-posterior diameter of about two inches, and a maximum transverse diameter of about. four inches. The opening is bounded behind by the anterior aspect of the body of the first thoracic vertebra, on each side by the inner border of the first rib, and in front by the posterior edges of the first costal cartilages and of the upper border of the sternum. Owing to the forward projection of the body of the first thoracic vertebra, the outline of the aperture is somewhat kidney-shaped. The plane of the opening slopes downwards and forwards, and corresponds with the plane occupied by the first pair of ribs. The student should remember that in the living subject the median part of the opening is occupied by the oesophagus and the trachea, and by the great blood-vessels of the neck and arm as they enter and leave the thoracic cavity. The vagus, the phrenic, and the left recurrent laryngeal nerves and the thoracic duct are also among the important structures passing through the median part of the opening. The lateral part of the aperture is occu-

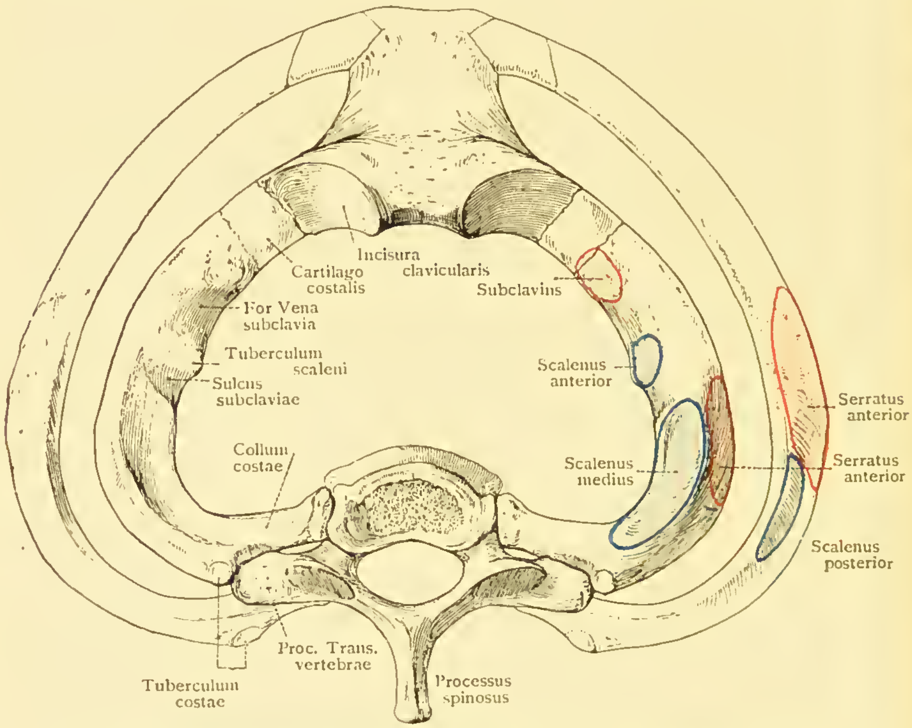

FIG. 23.—Superior aperture of the thorax. The disposition of the second ribs is also illustrated.

pied by the apex of the corresponding lung covered by its pleural sac.

The large **apertura inferior**, sometimes called the *thoracic outlet*, is bounded in front by the processus xiphoideus; on each side by the costal cartilages of the seventh to the eleventh ribs; and behind by the twelfth ribs and the twelfth thoracic vertebra. The boundary of the aperture extends to a lower level on each side than it does in front and behind; and the anterior part of the boundary lies higher than the posterior. In the living subject this opening is closed by the arching fibro-muscular partition forming the diaphragm, which here separates the thoracic from the abdominal cavity.

Below the sternum, the costal cartilages of the ribs of opposite sides, as seen from in front, form an arch, known as the **angulus infrasternalis**, or subcostal arch, from the apex of which the processus xiphoideus projects downwards.

If the cavity of the chest be examined by viewing it through the lower aperture, it will be seen that it is distinctly wider from side to side than from before backwards, and that the bodies of the thoracic vertebrae projecting forwards into the cavity reduce its antero-posterior diameter. On each side of the column formed by the bodies of the vertebrae is a deep and wide longitudinal groove, the **sulcus pulmonalis**, which receives the thick posterior part of the corresponding lung. It will be noticed that the backward direction of the part of each rib between the capitulum and angulus is largely responsible for the depth of the sulcus pulmonalis. As a result of the backward sweep of this part of the ribs, the supporting column formed by the bodies of the vertebrae is brought forwards towards the line through which the centre of gravity of the trunk passes. A horizontal section of the chest cavity would exhibit a somewhat kidney-shaped outline, the notch or hilus being posterior and corresponding with the position of the bodies of the vertebrae. In lower mammals the chest cavity is deeper from before backwards than from side to side, and there is no deep recess on each side of the bodies of the vertebrae, as in man.

THE UPPER LIMB.

The study of the skeleton of the upper extremity should be begun by an examination of the *shoulder-girdle* (**cingulum extremitatis superioris**) formed by the scapula, or shoulder-blade, and the clavicle, or collar-bone. The **scapula** is a flattened, somewhat triangular plate of bone, which lies on the posterior aspect of the thorax, to which it is connected by numerous muscles. It articulates with the bone of the upper arm, or humerus, at the shoulder-joint, and at a slightly higher level it joins the outer end of the clavicle, being firmly bound to the latter by strong ligaments. The **clavicula**, or clavicle, is a long bone placed nearly horizontally in front of the upper part of the chest. Its inner end is connected with the upper part of the sternum and the costal cartilage of the first rib; its outer end articulates with the scapula above the shoulder-joint. By placing his right hand upon his left shoulder the student will readily recognize that the shoulder-girdle is capable of being moved to a considerable degree, and that the shoulder region can be raised or depressed, brought forward or drawn backwards. This mobility of the shoulder-girdle greatly increases the range of movement of the upper limb.

THE SCAPULA.

The **scapula** has the form of a flattened triangular plate with two outstanding processes, and lies behind the posterior and upper part of the thoracic wall, extending from the level of the second rib above to that of the seventh rib below. The student will readily distinguish the two surfaces of the bone: the **facies costalis**, which looks forwards and inwards, is irregularly hollowed out; while the **facies dorsalis**, which looks backwards and outwards, is subdivided into an upper and a lower part by a shelf-like projection called the **spina scapulae**.

The angles of the scapula are named **angulus medialis**, or superior angle, **angulus inferior**, and **angulus lateralis**. The position of the angulus inferior is readily recognized in the living subject; that of the angulus medialis is less easily determined, as it is covered by a thicker mass of muscle. The angulus lateralis of the scapula is strong and massive, and

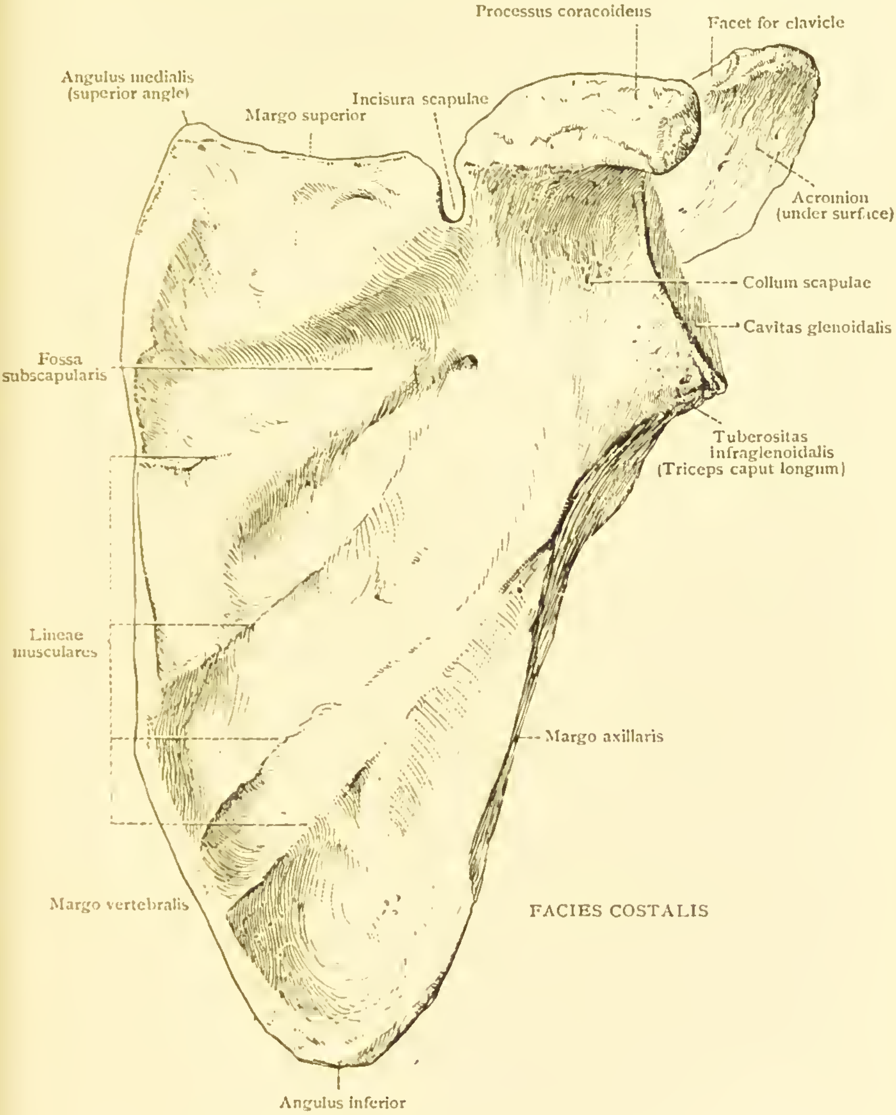

FIG. 24.—Left scapula seen from in front.

forms a large shallow articular fossa—**cavitas glenoidalis**—for articulation with the humerus.

The three borders of the scapula are of unequal length: the longest is the **margo vertebralis**; the shortest the **margo**

superior; the **margo axillaris**, which is intermediate in length, is also the thickest.

The **margo vertebralis** extends downwards and slightly outwards from the angulus medialis (superior) to the angulus inferior. It gives attachment to three muscles, viz. levator scapulae, rhomboideus minor, and rhomboideus major, in this order from above downwards. These muscles connect the scapula with the cervical and upper thoracic portions of the columna vertebralis.

The **margo superior** lies nearly horizontally, and passes outwards from the angulus medialis (superior) to the angulus lateralis. A curious, thick, hook-like process, called the **processus coracoideus**, is attached to the outer part of the margo superior, and immediately to the inner side of this projection there is a notch, or depression, called the **incisura scapulae**. Before maceration this notch was bridged over by a ligament which converted the incisura scapulae into a foramen for the passage of the nervus suprascapularis. The accompanying artery (arteria transversa scapulae, or suprascapular) passed over the ligament. In some bones it will be noticed that ossification in the ligament has given rise to a foramen surrounded by bone. To the margo superior, in the region of the notch, a slender muscle called the omo-hyoideus is attached.

The **margo axillaris**, so named from its relationship to the arm-pit, or axilla, begins above at the angulus lateralis below the articular surface for the humerus, and runs downwards and inwards to the angulus inferior. In its upper part, just below the articular fossa, this border of the scapula is thick and rough, forming the **tuberositas infraglenoidalis**, and gives origin to a part (caput longum) of the triceps muscle.

The greater part of the **facies costalis scapulae** is distinctly concave, and forms a hollow called the **fossa subscapularis**. It gives origin to a thick mass of muscle, the subscapularis, which passes in front of the shoulder-joint to reach the humerus, and fills up a part of the interval between the scapula and the chest wall. On this surface the student will notice a series of rough ridges beginning at the margo vertebralis, and fading away as they converge towards the angulus lateralis. These, the **lineae musculares**, give attachment to tendinous septa developed in the muscle. Along the margo vertebralis there is a narrow flat area, which widens above near the angulus medialis and below at the angulus inferior, and

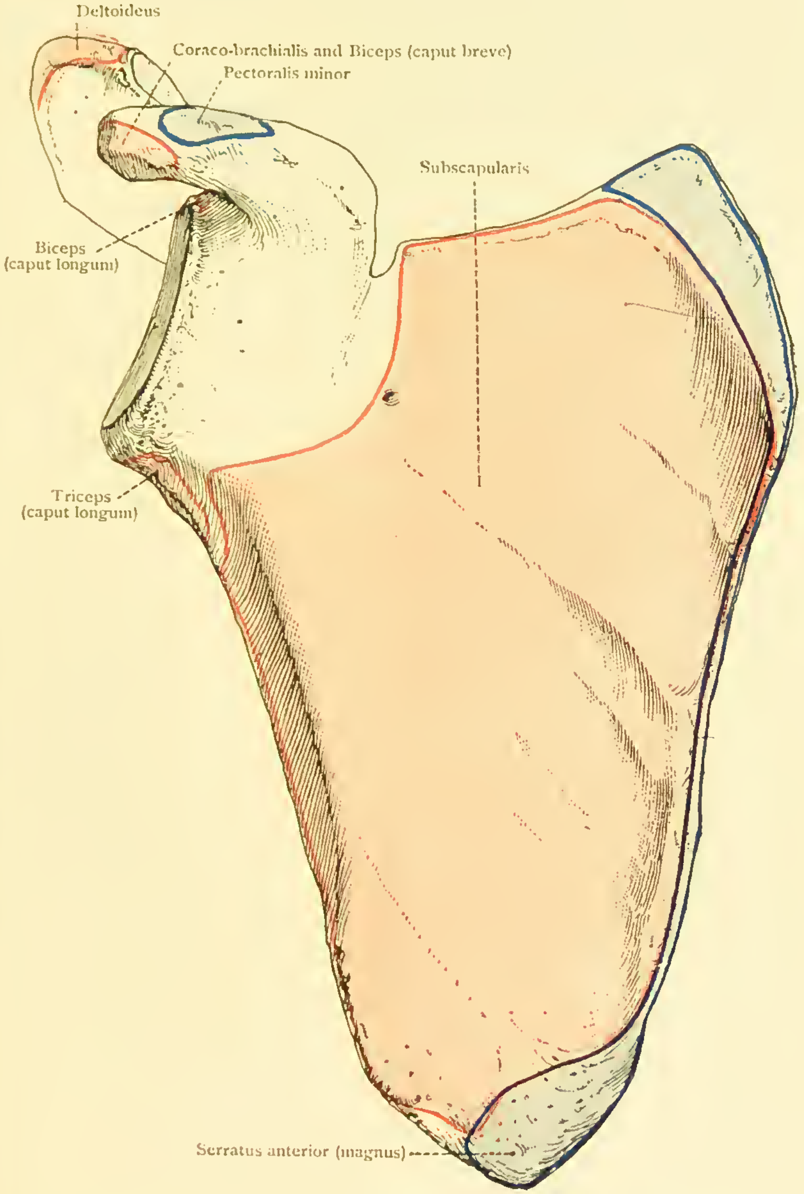

FIG. 25.—Right scapula seen from in front, to show attachment of muscles.

gives insertion to the powerful serratus anterior (or magnus) muscle. This muscle connects the scapula with the side wall of the chest, taking origin from the upper nine ribs; like the

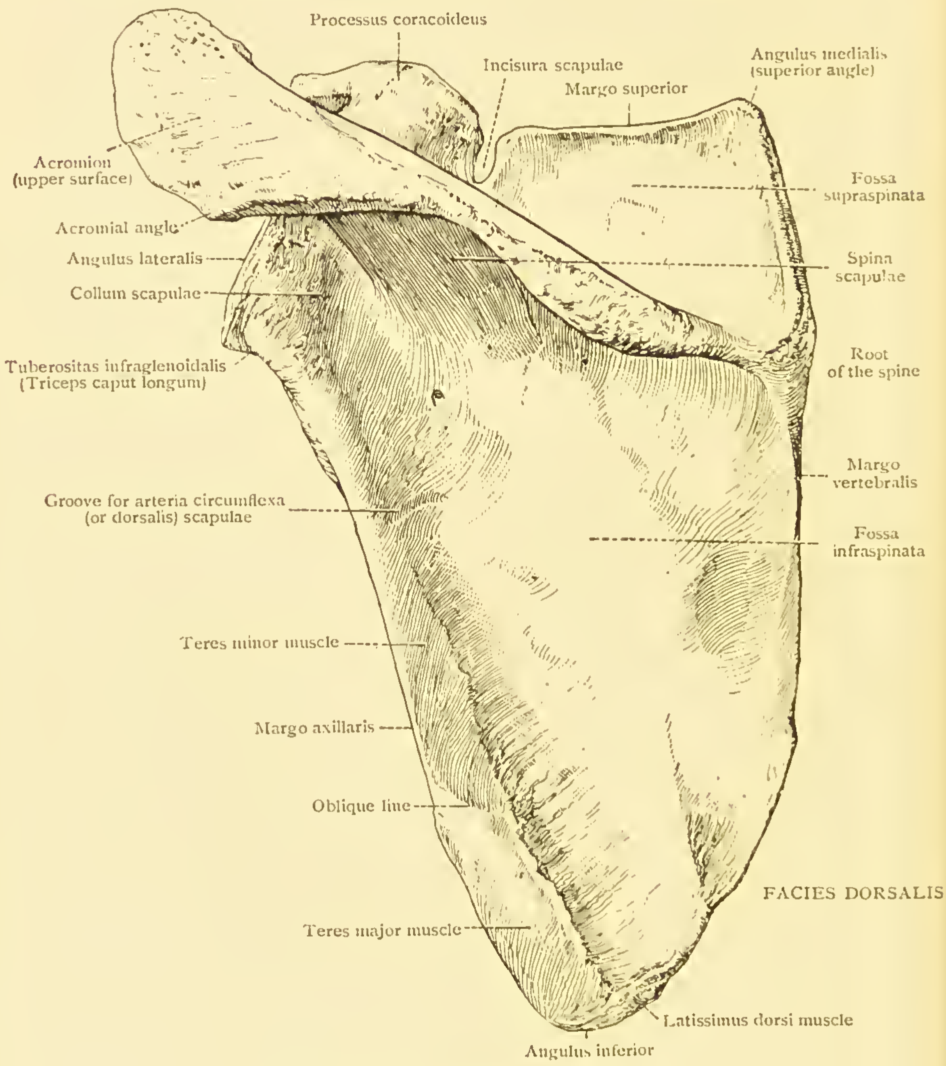

FIG. 26.—Left scapula seen from behind.

subscapularis it intervenes between the facies costalis scapulae and the posterior aspect of the chest wall.

The **facies dorsalis scapulae** is subdivided by the backwardly projecting spina scapulae into a small **fossa supra-**

spinata, and a larger **fossa infraspinata**. These fossae give origin to the supraspinatus and infraspinatus muscles, which pass one above and the other behind the shoulder-joint to reach the humerus. The dorsal surface of the angulus inferior is overlapped by the upper border of the great latissimus dorsi muscle, and, as it crosses the bone, the muscle often has a slight attachment to this part of the scapula. Close to the margo axillaris, and near the angulus inferior, the student will observe a somewhat rough, flat area which corresponds to the origin of the teres major muscle. This area is marked off from the rest of the facies dorsalis by an obliquely running line. The narrow raised district along the upper part of the margo axillaris gives origin to the teres minor muscle. A careful search usually reveals one or more grooves for branches of the arteria circumflexa (or dorsalis) scapulae on the surface of the bone which gives attachment to this latter muscle.

The **spina scapulae** possesses smooth triangular upper and under surfaces. The former looks upwards, forwards and inwards, and forms a part of the fossa supraspinata ; the latter looks downwards, backwards and outwards, and forms the upper limit of the fossa infraspinata. By its anterior border the spine is attached to the facies dorsalis scapulae. It is important to note that this attachment does not extend the whole way from the margo vertebralis to the angulus lateralis scapulae, but that an interval is left, near the angulus lateralis, where the fossa supraspinata communicates directly with the fossa infraspinata. This communication between the two fossae is known as the *great scapular notch*, and permits the blood-vessels and nerves to pass, during life, from the upper into the lower fossa. If a finger be placed in the great scapular notch, and pressed in the direction of the margo vertebralis scapulae, the outer limit of the spine will be readily recognized. It is formed by a rounded, smooth border along which the upper and under surfaces of the spine meet. The flattened piece of bone which overhangs the notch, and springs from the outer and posterior part of the spine, is known as the **acromion**. Its under surface is joined by the outer border of the spine, and lies over the shoulder-joint. The posterior border of the spine lies subcutaneously, and its position and form can be easily determined in the living subject. On this border we recognize an upper and an under edge, separated by a rough interval, varying in width in different parts of the spine. The upper edge gives insertion to fibres of the trapezius muscle, while the lower affords origin to a part of the deltoideus.

Where the posterior border of the spine joins the margo vertebralis scapulae, there is a small triangular area, known as the *root of the spine*, over which a tendon of the trapezius muscle glides. If the posterior border of the spine be traced outwards it will be seen that its upper and lower edges separate so as to enclose between them the upper surface of the acromion.

The upper surface of the **acromion** looks upwards and backwards, and like the posterior border of the spine, with which it is continuous, it is sub-cutaneous.

The outline of its external border, from which fibres of the deltoideus spring, can be readily determined during life. This border is continuous with the lower edge of the posterior border of the spine, and at first runs mainly outwards and then turns almost directly forwards; an angle—known as the *acromial angle*—being formed where it suddenly changes its direction. The acromial angle is an important landmark in the living subject, and is used as a fixed point in making measurements of the upper extremity. It can easily be identified by the student in his own shoulder, if the hand of the opposite side is passed across the front of the chest.

At the anterior extremity, or tip, of the acromion its outer and inner borders meet. The inner border is continuous with the upper edge of the posterior border of the spine, and like the latter, gives insertion to the fibres of the trapezius muscle. On the anterior part of the inner border, a smooth elongated oval facet, the **facies articularis acromii**, may be seen for articulation with the outer end of the clavicle. This articular surface, which is often badly marked, looks upwards, inwards and forwards; it is obvious that there is no interlocking of the two bones at the acromio-clavicular articulation.

The **angulus lateralis**, or *head of the scapula*, next demands our attention. It is the strongest part of the scapula, and supports a smooth pear-shaped facet forming the **cavitas glenoidalis**, or *glenoid fossa*. The articular surface is wider below than above, and forms a very shallow socket which looks outwards, upwards, and slightly forwards for the head of the humerus. During life the cavity is rendered deeper by the attachment all round its margin of the labrum glenoidale, or glenoid ligament. Below the fossa is the rough **tuberositas infraglenoidalis** for the caput longum of the triceps muscle, and just above it is a small, slightly marked area, the **tuberositas supraglenoidalis**, for the origin of the caput longum of the biceps muscle.

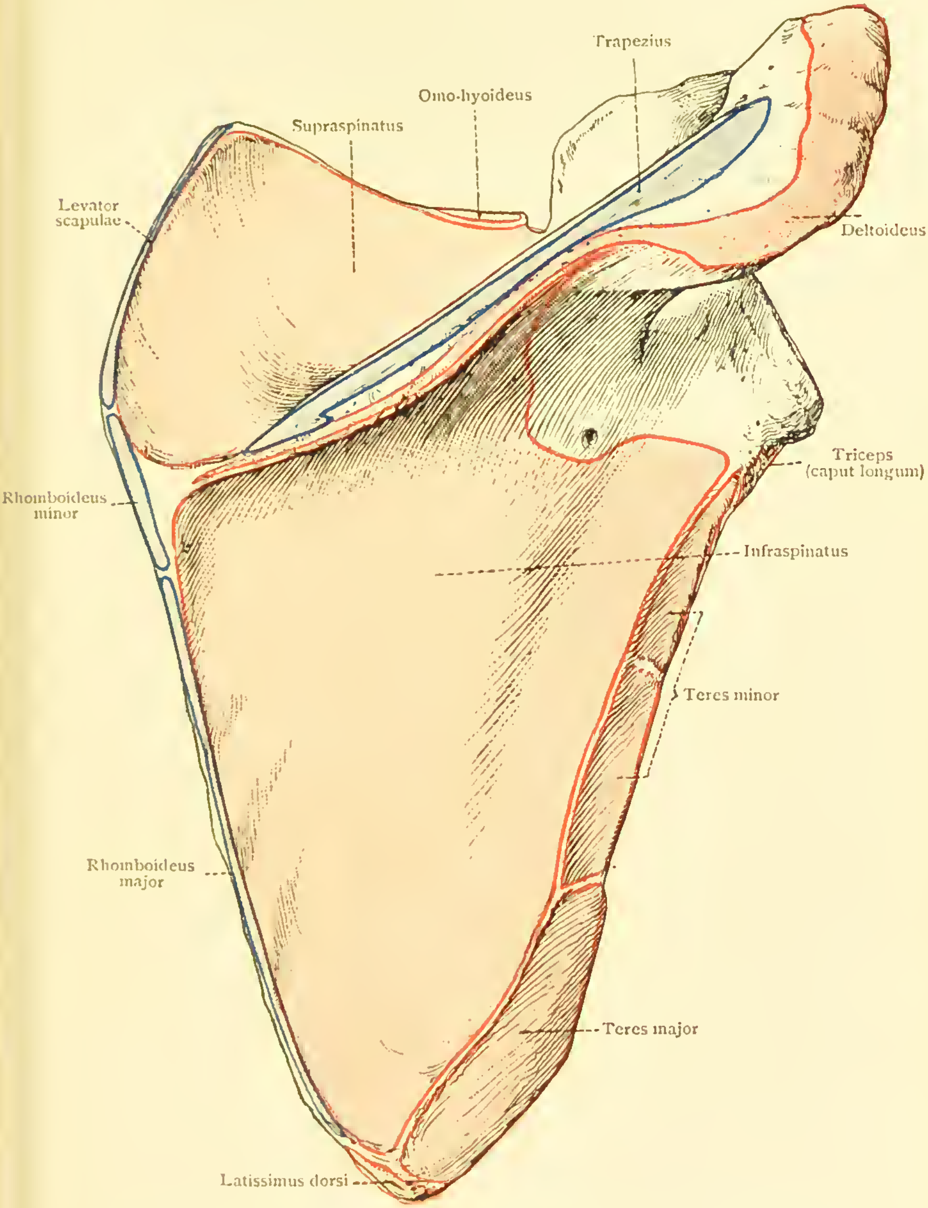

FIG. 27.—Right scapula seen from behind, showing the muscular attachments.

Immediately above the cavitas glenoidalis, the **processus coracoideus** springs from the upper part of the head of the scapula. The process, which is shaped like the two last joints of the bent little finger, consists of two parts, one almost vertical and the other almost horizontal. The vertical portion of the processus coracoideus is attached to the scapula, and is compressed from before backwards. The horizontal part is directed forwards and outwards, and ends in a rounded tip, which may be felt in the living subject by pressing back-

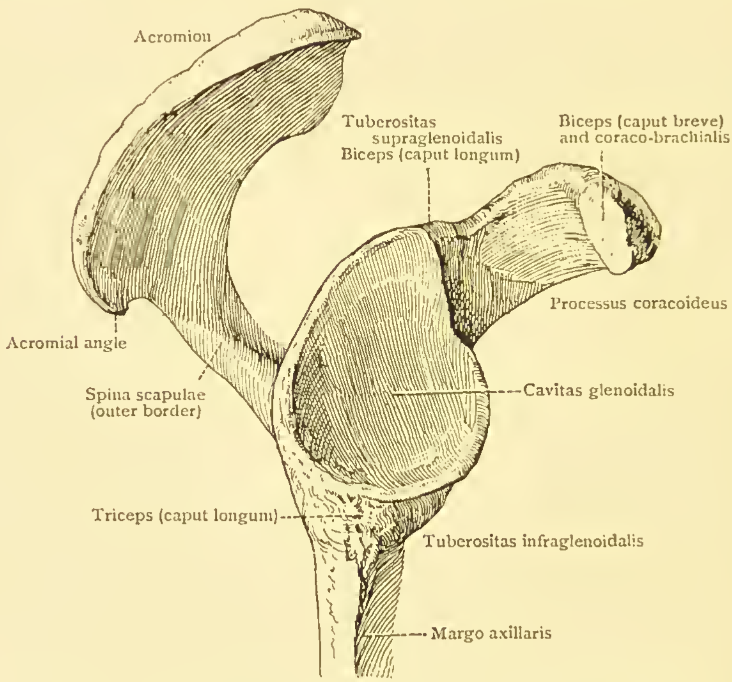

FIG. 28.—Right scapula; parts related to the shoulder-joint.

wards and outwards in the outer part of the depression below the clavicle. Three muscles are attached to the coracoid process;—from the tip the coraco-brachialis and short head of biceps take origin by a conjoined tendon; into the anterior border of the horizontal portion, the pectoralis minor muscle is inserted. The rough ridge on the processus coracoideus, which separates the posterior surface of the vertical from the upper surface of the horizontal portion is important, as it indicates the line of attachment of the very strong ligamentum coraco-claviculare, which binds the outer end of the clavicle down to the scapula. It is well that the student should note that the processus coracoideus forms the outer boundary of the incisura scapulae, already described, on the margo superior of the scapula.

One of the more common forms of fracture of the scapula begins above at the incisura scapulae, and passes downwards, through the floor of the great scapular notch, to reach the margo axillaris, immediately below the tuberositas infraglenoidalis. In such a fracture, the head of the scapula with the attached processus coracoideus is separated from the rest of the bone to which the spine and acromion are fixed. An examination of the region, determined by the line indicated, shows that the bone is flattened, and compressed from before backwards in this position; hence the term **collum scapulae**, or neck, is given to this part of the bone.

Before completing his study of the scapula, the student should carefully note the position of the acromion and processus coracoideus in relation to the shoulder-joint. He will find that they project over the joint, and form a protecting arch above the upper end of the humerus and its attached tendons. A strong ligament, the ligamentum coraco-acromiale, connects the processes, during life, and completes the arch.

In lower animals the margo vertebralis is the shortest of the three borders, and the supraspinous and infraspinous portions of the scapula are of approximately equal size. The entire bone appears as if made up of three plates, united together along an axis passing from the centre of the cavitas glenoidalis to the middle point of the margo vertebralis. These three plates are the spine and the supraspinous and infraspinous portions of the scapula. In reptiles and birds the coracoid is represented by a separate bone, which takes a share in the formation of the socket for the head of the humerus, and reaches from this socket to the sternum.

THE CLAVICULA.

The **clavicula**, *clavicle*, or collar-bone, connects the scapula, and through it the superior extremity, with the trunk. In the living subject its position can be accurately observed, and its general form determined, as its smooth upper surface is readily felt beneath the skin. The bone lies nearly horizontally; its inner end or **extremitas sternalis**, articulates with the upper part of the sternum, and its outer end or **extremitas acromialis**, joins the acromion process of the scapula.

If the student pass his fingers over his own clavicular region, he will have no difficulty in recognizing that near the extremitas sternalis the clavicula is thick, somewhat cylindrical, and curved so as to be convex forwards; while towards the extremitas acromialis, the bone is flattened from above downwards, and its anterior border recedes, the clavicula in this position being curved so as to be concave forwards.

Turning his attention to the macerated bone, the student should recognize (1) the thick extremitas sternalis; (2) the flattened extremitas acromialis; (3) the smooth upper surface of the bone; (4) the anterior convexity and the cylindrical nature of the inner two-thirds; and (5) the anterior concave edge and the flattened nature of the outer third of the bone. The under aspect of the bone is by no means so smooth as the

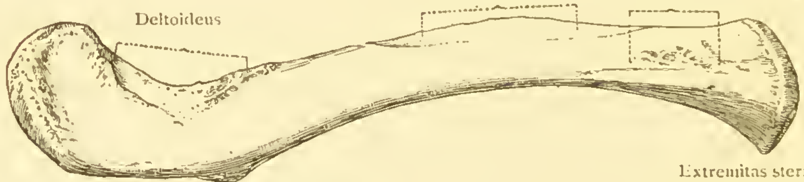

FIG. 29.—Left clavicle from above.

upper, and this is especially the case near each of the extremities, where the under aspect usually shows very distinct rough impressions for strong ligaments.

The **facies articularis sternalis**, or *sternal facet*, usually somewhat convex from before backwards, and slightly concave from above downwards, is continued to a slight extent on to the under aspect of the sternal end of the bone; this surface is in contact with a plate of fibro-cartilage which, in the living subject, separates the clavicula from the incisura clavicularis of the sternum and from the inner part of the first costal cartilage. The prominent upper, anterior, and posterior margins of the **extremitas sternalis** give attachment to the interclavicular and sterno-clavicular ligaments.

The **extremitas acromialis** is flattened from above downwards, and the oval-shaped articular facet which it bears for the acromion looks downwards, outwards, and backwards. In many bones this *acromial facet*, or **facies articularis acromialis**, is badly defined.

The shaft which connects the extremities may, as we have seen, be divided into an inner two-thirds, somewhat cylindrical and convex forwards; and an outer third, flattened from above downwards and concave forwards. The anterior curve of the inner part affords room for the passage of the great nerves and blood-vessels from the root of the neck to the armpit. The inner part of the shaft gives attachment on its anterior aspect to a portion of the pectoralis major muscle; on its upper surface to a part of the sterno-cleido-mastoideus; posteriorly, over a small area, to the sternohyoideus and sternothyroideus muscles; and inferiorly to the strong ligamentum costo-claviculare, or rhomboid ligament. The region of attachment of the latter structure is usually a well-marked impression, the **tuberositas costalis**, or *rhomboid impression*,

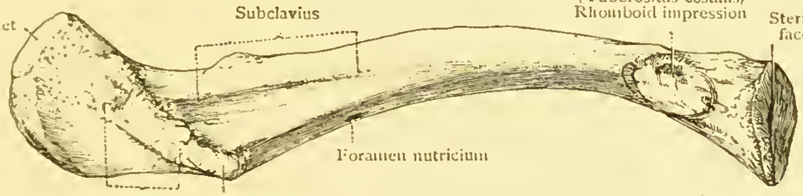

FIG. 30.—Right clavicle from below.

which lies about half-an-inch from the extremitas sternalis. The costo-clavicular ligament is short and strong, and limits the amount of upward movement of the clavicula.

The anterior border of the outer third of the bone is sharp and rough, and gives origin to fibres of the deltoideus; the posterior border is deeper, and gives insertion to a part of the trapezius. On the under aspect of the outer part of the bone there is a rough mark, the **tuberositas coracoidea**, which often begins posteriorly as a slight tubercle, the *conoid tubercle*, from which a ridge, called the *trapezoid ridge*, runs forwards and outwards towards the acromial articular facet. This tubercle and ridge mark the attachment of the ligamentum conoideum and the ligamentum trapezoideum, which together form the strong ligamentum coraco-claviculare, and bind the clavicula down to the processus coracoideus. A smooth, shallow, longitudinal sulcus for the insertion of the subclavius muscle may be seen on the under aspect of the clavicula, to the inner side of the ridge just mentioned.

A minute opening, the **foramen nutricium**, for the nutrient artery of the bone, may usually be found on the under, or on the posterior aspect of the clavicula.

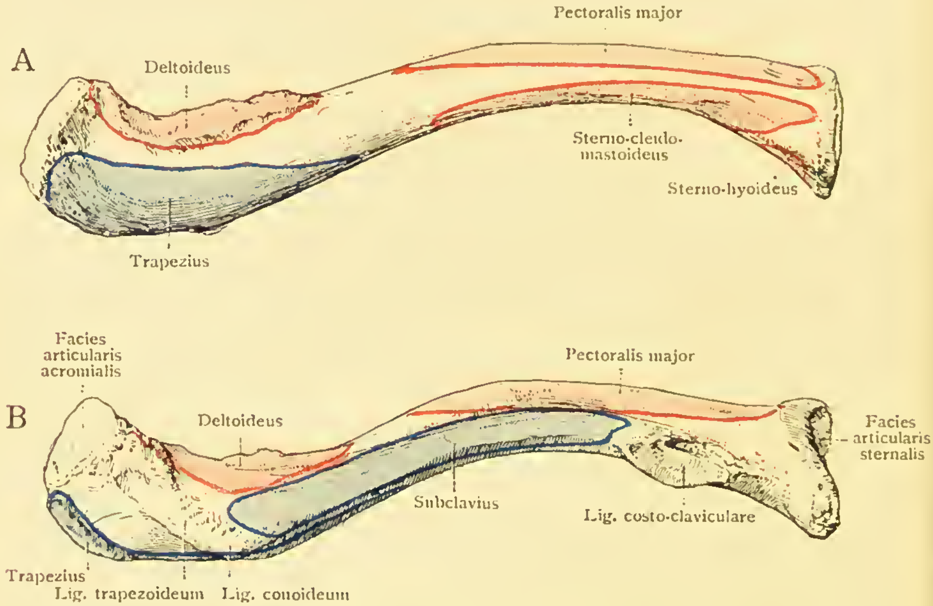

FIG. 31.—A, left clavicle from above ; B, right clavicle from below.

THE SHOULDER-GIRDLE.

Having made himself familiar with the form of the scapula and clavicula, and having identified, and noted the significance of, the various markings already described, the student should select bones belonging to the same side, and study the manner in which they articulate with one another and form the shoulder-girdle. When the bones are placed in proper position, it will be clear that there is no interlocking at the acromio-clavicular joint. It will be noted that the rough ridge on the upper part of the processus coracoideus lies immediately beneath the corresponding ridge on the under surface of the outer end of the clavicle. The very short and strong ligaments which unite these two ridges are mainly responsible for the strength of the joint between the clavicula and scapula. The direction of the ligaments is such as to prevent the clavicula slipping upward and outwards over the acromion.

The backward sweep of the outer end of the clavicle explains why the tip of the processus coracoideus can be felt in the living subject as it passes forwards beneath the collar-bone.

The extensive origin of the deltoideus from the shoulder-girdle can now be studied. The lower edge of the posterior border of the spina scapulae, the outer border of the acromion, and the anterior border of the outer end of the clavicula, will be seen to form a continuous curved line of origin, from which the fibres pass downwards as a fleshy cap over the shoulder-joint. The line of the insertion of the trapezius corresponds closely with the origin of the deltoideus. The insertion of the former muscle is into the upper edge of the posterior border of the spina scapulae, the inner border of the acromion, and the posterior border of the outer part of the clavicula. The surface of bone that intervenes between the origin of the deltoideus and the insertion of the trapezius lies subcutaneously.

The inner end of the clavicula should now be placed upon the corresponding incisura clavicularis of the sternum, and the relationship of the clavicula, sternum, and first costal arch carefully noted. Here also there is but little interlocking of the bones, but the clavicula is firmly bound down to the sternum and first costal cartilage, by the strong sterno-clavicular and costo-clavicular ligaments already noted. It will be clear from a study of the parts, that a slight degree of mobility at this end of the clavicula will permit a relatively wide range of movement at the outer end.

The outer end of the clavicula, and the region of the shoulder which it supports, can be moved in the circumference of a circle, the centre of which lies at the sterno-clavicular articulation, and the radius of which is mainly formed by the clavicula. Further, these movements may take place in horizontal, vertical, or in oblique planes. When the arm is raised high above the shoulder, the outer end of the clavicula is raised, the scapula is tilted, so that the cavitas glenoidalis comes to look more upwards than when the arm hangs by the side of the body. Similarly, when the arm is brought forwards, as in 'hitting out from the shoulder', the scapula is drawn round the side of the chest, and the cavitas glenoidalis comes to look more directly forwards. In movements such as these, the range of displacement is relatively great at the outer end of the clavicula, but very slight at its inner end. In the articulated skeleton, the district behind the clavicula, and the interval between the clavicula and the first rib should be explored with the tips of the fingers. This region is of importance, as in the living subject it is occupied by the great blood-vessels and nerves which enter the superior extremity.

The existence of a well-developed clavicula is associated with a wide range of movement of the upper limb; for when the clavicula is long, the shoulder-joint is maintained at the side and not on the ventral aspect of the trunk. We might, indeed, regard the clavicula as a prop, keeping the shoulder out in its correct position; hence, when the clavicle is fractured, the shoulder falls inwards and forwards. Wide shoulders are associated with well-developed claviculae; in animals with narrow shoulders, such, for instance, as cats and horses, the claviculae are absent or vestigial.

It is interesting to note that in the lower groups of animals, the fixation of the shoulder-girdle to the sternum is mainly affected by means of a bone called the coracoid, which is represented by a part of the processus coracoideus of man. In the great group mammalia, except in the monotremata, the coracoid bone has become reduced to a mere process of the scapula, and no longer reaches the sternum.

THE HUMERUS.

The **humerus**, or bone of the upper arm, being the largest of the bones of the upper extremity, is easily recognized by its size and general form. On its upper end will be noticed a smooth articular surface, forming about one-third of a sphere, for articulation with the cavitas glenoidalis of the scapula. This is known as the **caput humeri**, and is directed upwards, inwards, and slightly backwards. Close to the caput humeri there are two well-marked tuberosities, namely the **tuberculum majus** which forms the outer part of the upper end of the humerus, and the **tuberculum minus** which is more conical, and projects directly forwards.

The outer aspect of the **tuberculum majus** is continuous with the outer surface of the shaft, or **corpus humeri**; its upper and posterior part shows three smooth impressions corresponding to the insertions of the tendons of the supraspinatus, infraspinatus, and teres minor muscles, in this order from above downwards and backwards; its anterior border forms the outer limit of a well-marked vertical sulcus, the **sulcus intertubercularis**, or *bicipital groove*, which is continued downwards on the anterior aspect of the shaft, and transmits the tendon of the long head of the biceps muscle.

The **tuberculum minus** lies to the inner side of the upper part of this groove, and projects, as we have seen, directly forwards. It shows upon its summit an impression for the

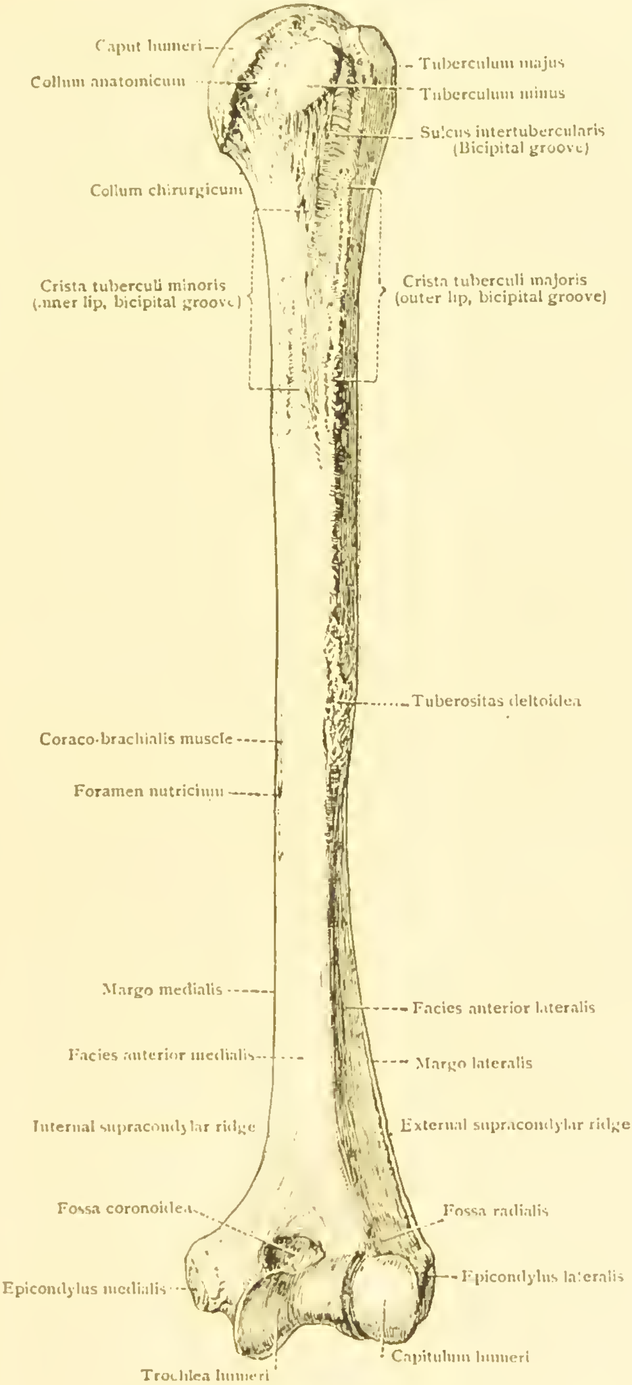

Fig. 32.— Left humerus from in front.

insertion of the tendon of the subscapularis muscle. The tuberosities afford leverage to the important muscles which are inserted into them, and which move the humerus at the shoulder-joint.

Separating the tuberosities from the caput humeri there is a slightly marked shallow sulcus, termed the **collum anatomicum**, which gives attachment to the fibrous capsule of the shoulder-joint. Above, in front, and behind, the line of attachment of the capsule lies close to the margin of the articular surface, but towards the inner and under aspect, the capsule of the shoulder-joint is attached at some little distance below the margin of the articular surface of the head.

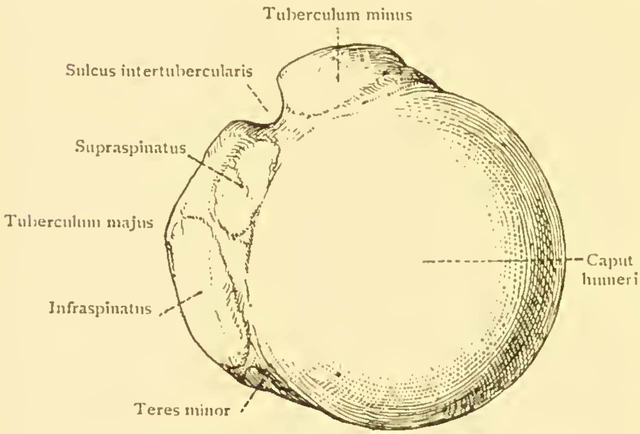

FIG. 33.—Upper end of left humerus from above.

The region below the caput humeri and the tuberosities, where the expanded upper part of the bone joins the shaft, is known as the **collum chirurgicum**, or surgical neck.

The shaft, or **corpus humeri**, is somewhat cylindrical in its upper part, and three-sided in its lower part. On the anterior aspect of its upper part we see the continuation of the **sulcus intertubercularis**, or bicipital groove, for the tendinous long head of the biceps muscle. The rough *outer lip* of this groove, or **crista tuberculi majoris**, gives insertion to the pectoralis major; the rough *inner lip*, or **crista tuberculi minoris**, gives insertion to the teres major, and the floor of the groove gives insertion to the latissimus dorsi muscle.

On the outer aspect of the shaft, near the middle, there is a large rough mark for the insertion of the deltoideus. This is called the **tuberositas deltoidea**, or *deltoid eminence*, and has a somewhat V-shaped outline. The anterior limit of the V-shaped mark is continued upwards into the outer lip of the groove for the biceps tendon, the posterior limb passes upwards and backwards, and ends on the posterior aspect of the upper part of the shaft by joining a slight ridge which gives origin to the caput laterale of the triceps muscle.

The inner aspect of the shaft, opposite to, and on a somewhat lower level than the insertion of the deltoideus, usually exhibits a rough vertical line, which indicates the insertion of the coracobrachialis muscle. In this position we often find an arterial foramen, the **foramen nutricium**, entering the bone in a downward direction.

In the lower third of the humerus, the shaft is triangular in cross-section, and possesses well-defined inner and outer borders which become more prominent as they are traced downwards; they end in two projections called **epicondylus medialis** and **epicondylus lateralis**. The term **margo lateralis**, or *external supracondylar ridge*, is applied to

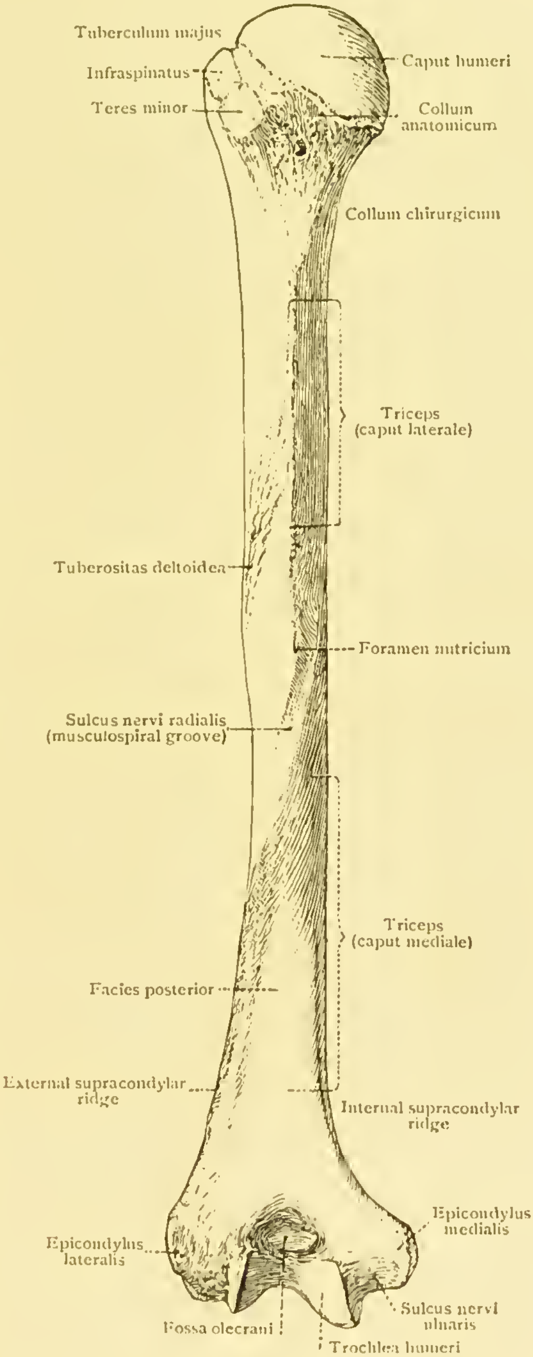

FIG. 34.—Left humerus from behind.

the outer border, and **margo medialis**, or *internal supracondylar ridge*, to the inner border. The anterior aspect of the shaft, between these two borders, is smooth and convex from side to side, and gradually increases in width as it is traced downwards. It gives origin to the brachialis muscle, and, by a rounded vertical elevation, it is subdivided into inner and outer portions—**facies anterior medialis**, and **facies anterior lateralis**. The **margo lateralis**, which is rough, and rolled somewhat forwards, gives attachment to the external intermuscular septum, and origin to the brachio-radialis and extensor carpi radialis longus muscles. The **margo medialis** gives attachment to the internal intermuscular septum.

The posterior aspect of the shaft in its lower part is flattened, and gives origin to the caput mediale of the triceps muscle.

An examination of the posterior and outer aspect of the shaft of the humerus gives one the impression that the bone has been twisted in its long axis, the region of the epicondylus lateralis having been brought forwards. This appearance is largely due to the presence of a smooth, wide, shallow sulcus, which takes a spiral course downwards and forwards round the outer aspect of the shaft, behind and below the tuberositas deltoidea, and above the upper end of the margo lateralis. This groove is known as the **sulcus nervi radialis** or *musculo-spiral groove*, and in it the nervus radialis, or musculo-spiral nerve, and the superior profunda artery (arteria profunda brachii) pass downwards. In the floor of the groove there may usually be found a nutrient arterial foramen, **foramen nutricium**, leading in a downward direction.

The lower end of the humerus is wide from side to side, compressed from before backwards, and bent somewhat forwards. When looked at from in front the following parts may without difficulty be identified: most externally lies the **epicondylus lateralis**; below and to the inner side of this is the **capitulum humeri**, a convex articular area for articulation with the head of the radius; next to this lies the **trochlea humeri**, a pulley-like articular area for the ulna; and then the **epicondylus medialis**, above and internal to the trochlea. Immediately above the trochlea there is a fossa, which receives the coronoid process of the ulna when the elbow-joint is completely flexed. It is called the **fossa coronoidea**. A less distinct depression lies above the capitulum, and is related to the head of the radius when the joint is flexed. This latter depression is the **fossa radialis**.

On the posterior aspect of the lower end of the humerus we

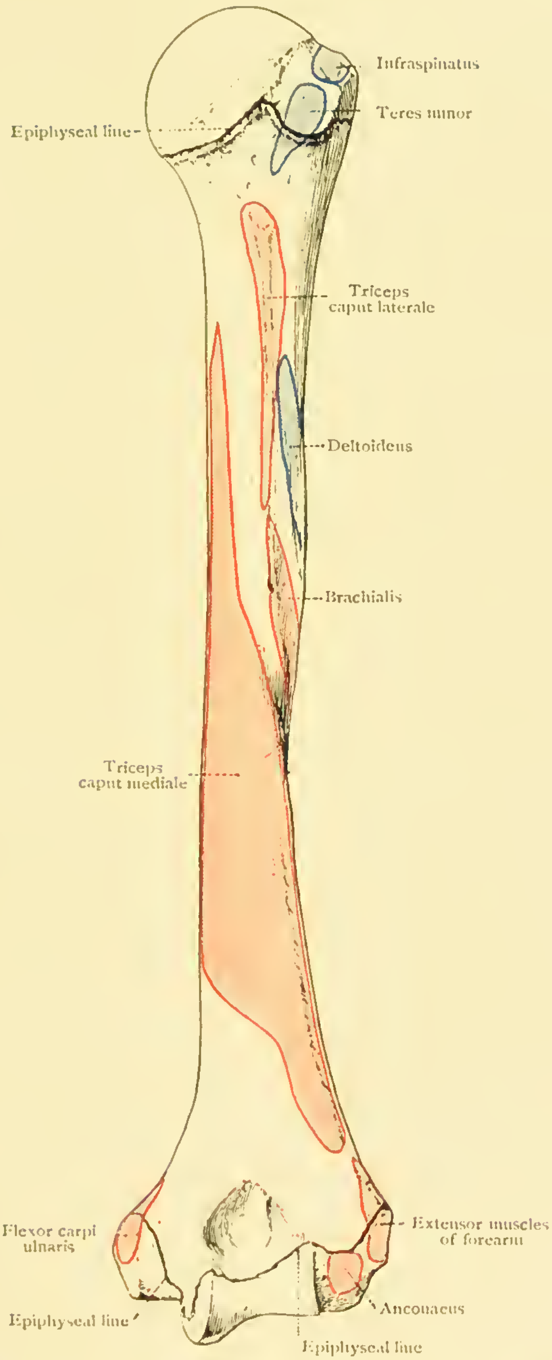

FIG. 35.—Right humerus from behind, to show attachment of muscles. From a young subject.

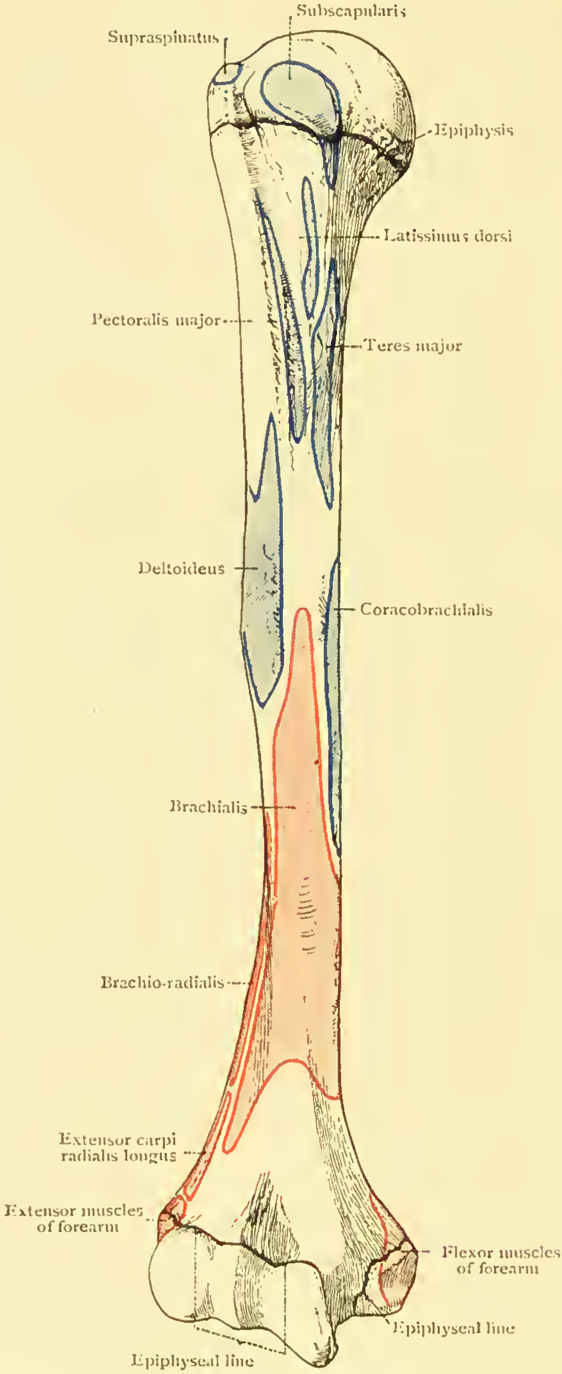

FIG. 36.—Right humerus from in front, to show attachment of muscles. From a young subject.

recognize a part of the trochlea humeri for the ulna, and above it a large deep depression, the **fossa olecrani**, into which the olecranon of the ulna fits in extension of the elbow-joint. On this aspect of the bone there is no articular surface for the radius, and the part of the bone which lies behind the capitulum slopes downwards and forwards, and gives attachment to the external lateral ligament, or ligamentum collaterale radiale, of the elbow-joint, to the anconaeus, and to the common tendon of the extensor muscles of the forearm. To the inner side of the trochlea, between it and the epicondylus medialis, we find a groove — **sulcus nervi ulnaris** — on the posterior aspect of the bone. In this lies the ulnar nerve as it passes behind the elbow.

Having identified these various parts, the student should examine each in detail. He will note that the **epicondylus lateralis** projects outwards only very little beyond the capitulum, and that the strong lower portion of the margo lateralis humeri is continued downwards and forwards into it. The outer aspect of the epicondylus shows an impression for the attachment of the common tendon of the extensor group of muscles. On a lower and anterior plane the liga-

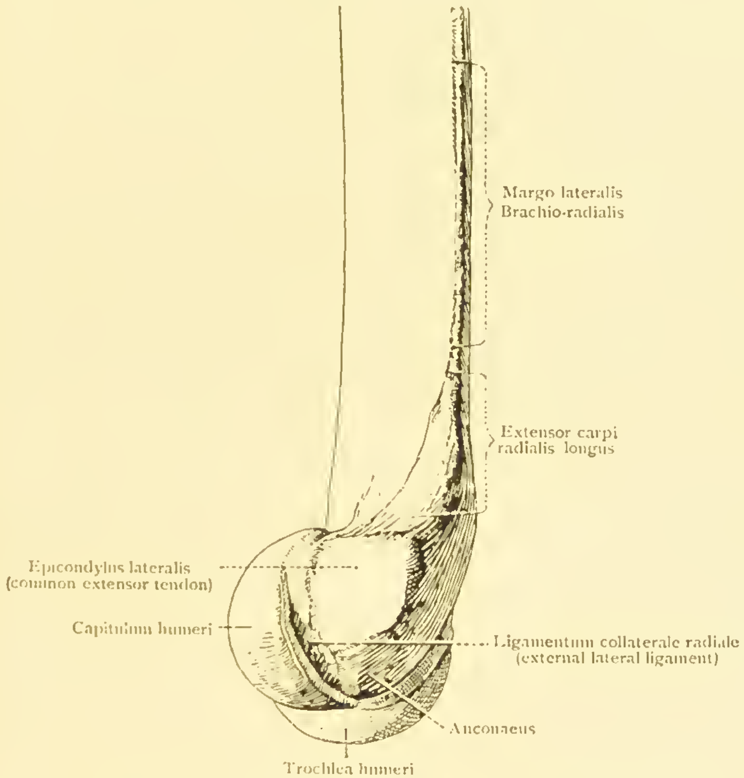

FIG. 37.—Lower end of left humerus from the outer aspect.

mentum collaterale radiale or external lateral ligament of the elbow is attached, and on a lower and posterior plane the anconaeus takes origin. The great strength of the bone where it supports, and articulates with the radius, and the firm support which the capitulum receives from the epicondyle and from the lower end of the margo lateralis, should be noted.

The articular surface of the **capitulum** forms a part of a sphere; it is directed forwards, and is far smaller than that of the trochlea with which it is continuous; a smooth shallow sulcus alone indicating their separation. The concave upper articular surface of the head of the radius rests against the capitulum humeri, the bones being most accurately in apposition when the elbow-joint is midway between flexion and extension.

The deeply grooved articular surface for the ulna, forming the **trochlea humeri**, winds obliquely round the under surface of the humerus from the posterior to the anterior aspect of the bone. The axis of the pulley-like trochlea lies obliquely to the long axis of the humerus, and its inner margin is sharply defined and far more prominent than its outer. It will be

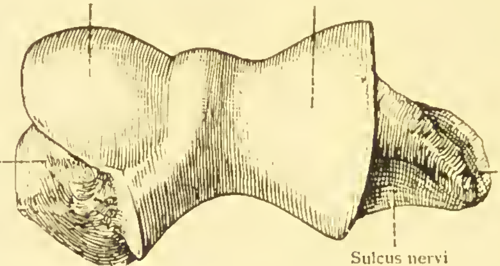

FIG. 38.—Lower end of right humerus from below.

noticed, however, that on the posterior aspect of the humerus the contrast between the inner and outer lips of the trochlea is not so marked as on the anterior aspect. The great articular cavity of the upper end of the ulna, known as the incisura semilunaris, or greater sigmoid fossa, embraces the trochlea of the humerus, the two bones interlocking in a very perfect fashion. The student should note that the deep groove on the trochlea crosses the lower end of the humerus by passing slightly inwards as well as forwards.

The **epicondylus medialis** forms a more marked projection than the lateral epicondyle, and is very readily felt in the living subject. It is somewhat flattened from before backwards and gives origin to the pronator teres, the common tendon of the flexor group of muscles, and also the ligamentum collaterale ulnare or internal lateral ligament of the elbow-joint. Posteriorly, as we have seen, it is grooved by the ulnar nerve. The epicondylus medialis projects so much, and lies so free from the articulation of the elbow-joint, that, as a result of an accident, it is sometimes detached from the rest of the bone without the joint cavity being involved.

The capsule of the elbow-joint is attached, in front, to the lower end of the humerus immediately above the fossa coronoidea and fossa radialis; posteriorly, it is attached immediately above the fossa olecrani.

It can be readily demonstrated that the plate of bone which intervenes between the fossa coronoidea, and the fossa olecrani, is very thin and translucent; it is sometimes perforated by a foramen, as is normally the case in some animals. Such a perforation of the lower end of the humerus appears to occur more frequently in some races of mankind than in others.

ARTICULATION OF THE HUMERUS AND SCAPULA.

Before undertaking an examination of the bones of the forearm, the student is advised to select a humerus and scapula of the same side, and, having placed them together, to study the manner in which they articulate. The large size of the caput humeri is in marked contrast with the small size of the cavitas glenoidalis; it will also be noticed that there is no locking of the bones at the shoulder-joint, the articular surface of the humerus merely resting against the shallow fossa of the scapula. In this way a far greater freedom and range of movement is permitted than if a deep socket were present. The humerus is held in its shallow socket mainly by the action of the powerful muscles which surround the loose capsule of the joint. The shoulder-joint is a ball and socket articulation, and movement in all directions is permitted. The humerus may be brought forward and backward—flexion and extension; drawn away from, and drawn towards the side of the body—abduction and adduction; rotated on its long axis; or its lower end may be made to describe a circle, the whole bone in this movement outlining a cone the apex of which lies at the shoulder-joint. This latter movement is known as circumduction. When the humerus is abducted, its articular surface will be noticed to glide gradually more and more off the shallow fossa on the scapula. Dislocation is most likely to take place when the arm is fully abducted.

It is not possible to raise the arm beyond the horizontal position by movement at the shoulder-joint alone. When the arm is raised above this level, the scapula and clavicula are tilted, and the cavitas glenoidalis is turned so as to look more directly upwards. We have already seen that when the arm is thrust forwards, the scapula is brought forwards round the side wall of the chest, and the cavitas glenoidalis is turned so as to look more directly forwards. These movements of the scapula can be readily made out in the living subject, and they enable the scapula to form a firm basis of support to the humerus in the varying positions that it assumes.

It is important to remember that the tuberculum majus forms the most external bony projection in the region of the shoulder, and that the 'point of the shoulder' is formed by this part of the humerus, and not, as its name might lead one to believe, by the acromion. In accidents to the shoulder, the acromion often escapes and the humerus is injured, owing to the relatively more exposed position of the tuberculum majus. The position of the coraco-acromial arch with regard to the upper extremity of the humerus should be noted, and the relationship of the tip of the coracoid process to the tuberculum minus determined. When the arm hangs by the side of the trunk, the tip of the coracoid process lies above, on an anterior plane, and internal to the tuberculum minus.

THE FOREARM.

In the articulated skeleton it will be noticed that when the palm of the hand looks forwards, and the thumb points outwards, the bones of the forearm lie approximately parallel to one another. In this position, to which the term *supine* is applied, the inner bone is the ulna, the outer the radius. The bones of the forearm do not always occupy this parallel position; if the back of the hand be turned forwards, and the thumb directed towards the middle line, it will be found that the radius becomes obliquely placed in the forearm, its upper end lying to the outer side, its lower end to the inner side of the ulna. In this, the *prone* position, the shaft of the radius lies not parallel to, but obliquely across, the anterior aspect of the shaft of the ulna (fig. 47). The student should observe that in pronation—turning the hand so that its back looks forwards and the thumb points inwards—and in supination—turning the hand so that the palm looks forwards and the thumb points outwards—it is the radius that is moved in the manner already indicated. These movements are brought about by several muscles, called pronators and supinators, which are, of course, all inserted into the radius—the bone which is moved. It must be remembered that in describing the structures which form the hand and forearm, the parts are always regarded as occupying the positions in which they lie during supination.

It will be seen that of the two bones of the forearm the

ulna is the longer, that it is expanded above and takes chief share in the formation of the elbow, and that it is more slender below, having little part in the wrist-joint. The **radius** does not reach to so high a level as the ulna; takes but a small share in the elbow-joint; is more massive at its lower than at its upper end, and is mainly responsible for the support of the hand at the wrist-joint.

THE ULNA.

The **ulna** is massive at its upper extremity where it forms a great articular cavity, the **incisura semilunaris**, or *greater sigmoid fossa*, for the trochlea of the humerus; it tapers gradually towards its lower end where it terminates in a rounded **capitulum**, or *head*, and a short projecting **processus styloideus**.

The extreme upper end of the bone is formed by the **olecranon**, a projection which may be readily identified in the living subject since it lies subcutaneously and forms the point of the elbow. The upper surface of the olecranon, in its posterior part, gives insertion to the tendon of the powerful triceps muscle; the anterior aspect is smooth and articular, and forms the upper part of the incisura semilunaris. Where the upper

FIG. 39.—Left ulna from in front.

joins the anterior surface there is a somewhat beak-like projection, which fits into the deepest part of the fossa olecrani on the back of the lower end of the humerus during complete extension of the elbow-joint. From this beak a smooth ridge runs downwards on the articular surface subdividing it into inner and outer parts. The ridge fits into the deep groove on the trochlea humeri. The posterior surface of the olecranon is subcutaneous, and shows a number of longitudinal striae which give attachment to fibres derived from the triceps tendon. It is bounded by two borders which gradually approach one another and join, below the level of the olecranon, to form the posterior border of the shaft of the ulna.

When the ulna is viewed from in front it will be noticed that there is a slight constriction in the region where the olecranon joins the rest of the bone. The constriction cuts slightly into the incisura semilunaris at each side, and at this level the deepest part of this great articular cavity is crossed by a narrow non-articular sulcus, or depression. The part of the incisura semilunaris below the level of this sulcus is formed by the upper articular surface of the **processus coronoideus.** This latter process projects forwards and its apex, which forms a compressed transverse plate, fits during flexion of the elbow-joint into the fossa coronoidea of the humerus. The part of the articular surface of the trochlea formed by the processus coronoideus, like that formed by the olecranon, is subdivided into inner and outer portions by a smooth elevation. In the case of the coronoid, the inner subdivision, which articulates with the prominent inner lip of the trochlea, is considerably larger than the outer.

It will be noticed that, at the outer side of the incisura semilunaris, the articular surface is continued downwards on the outer, or radial, aspect of the coronoid process, and lines a shallow articular depression. This latter depression lodges the head of the radius, and is known as the **incisura radialis,** or *lesser sigmoid fossa.* It is concave from before backwards, and has well-marked anterior and posterior lips to which the ends of a strong ligament, the ligamentum annulare radii, or orbicular ligament are attached. In pronation and supination the upper end, or head of the radius rotates against the smooth surface of this depression, being held in place by the ligament which embraces it. It is important to remember that the cavity of the superior radio-ulnar joint, so formed, is continuous with the elbow-joint proper. The under and anterior aspect of the processus coronoideus slopes downwards and backwards, and joins the anterior aspect (facies volaris) of the shaft of the ulna. Immediately below the point of junction, there is a well-marked rough impression, or elevation, called the **tuberositas ulnae**, which, like the surface immediately above it, gives insertion to the brachialis muscle, a powerful flexor of the elbow-joint.

The shaft of the bone, or **corpus ulnae**, is somewhat curved in its long axis so as to be slightly concave forwards, and is three-sided in section.

It possesses a **margo dorsalis**, or *posterior border*, which begins above at the confluence of the two borders of the posterior surface of the olecranon, and ends below at the root of the processus styloideus. As it is traced from above downwards this border of the ulna has a slightly sigmoid course; it is subcutaneous throughout its whole length and can readily be felt in the arm of the living subject. The margo dorsalis gives attachment to the flat tendons of the flexor and extensor carpi ulnaris.

The outer border of the bone lies nearest the radius, and is called the **crista interossea**. In the middle third of the bone it is rough and sharp, and gives attachment to a strong membrane-like ligament, the membrana interossea antebrachii, which unites the bones of the forearm.

The third border of the ulna is named the **margo volaris**, and separates the anterior or facies volaris from the inner aspect, or facies medialis of the shaft.

The anterior aspect of the ulna, or **facies volaris**, lies between the crista interossea and the margo volaris. It is slightly concave from side to side and gives origin to a part of the flexor digitorum profundus. On this surface may be seen the **foramen nutricium**, for the nutrient artery of the ulna which is directed obliquely towards the upper end of the bone. About the junction of the lower fourth with the upper three-fourths of the bone, the facies volaris is crossed obliquely by a rough ridge which begins above at the crista interossea and ends below close to the root of the processus styloideus. This ridge and part of the bone, to its radial side, gives origin to the pronator quadratus muscle.

The **facies medialis** lies between the margo volaris and the margo dorsalis. It is smooth and slightly convex, and is continued upwards on to the inner surface of the processus coronoideus. Over practically the whole extent of this surface, fleshy fibres of the flexor digitorum profundus take origin.

Immediately below the incisura radialis there is a somewhat triangular depressed area which gives origin to the supinator (supinator brevis) muscle. The posterior boundary of this depression is formed by a prominent rough ridge (**crista musculi supinatoris**, or supinator crest) which reaches the posterior edge of the incisura radialis above, and joins the crista interossea below. The anterior limit is less well defined, and passes downwards and backwards from the anterior edge of the incisura radialis to join the crista interossea. The hollow in this part of the ulna affords room for the tuberositas of the radius when the forearm is in the position of pronation.

The **facies dorsalis** of the ulna lies between the margo dorsalis and the crista interossea, and is continued upwards on to the outer aspect of the olecranon. On its middle two-fourths, a vertical ridge marks off an outer and anterior narrow area, which lies immediately behind the crista interossea, and gives origin to the abductor pollicis longus (or extensor ossis metacarpi pollicis), the extensor pollicis longus, and the extensor indicis proprius muscles. The portion of the facies dorsalis which lies to the inner side of, and behind this vertical ridge, and immediately in front of the margo dorsalis, does not give origin to any muscle. The upper third of the facies dorsalis and the outer side of the olecranon afford insertion to the anconaeus muscle, the lower limit of its attachment being indicated by a faintly-marked line which runs obliquely downwards and backwards from the crista musculi supinatoris to join the margo dorsalis.

The lower end of the ulna becomes slightly expanded to form the small **capitulum**, or *head*, in which it terminates. The margin of the capitulum, in front and towards the radial side, is smooth, and covered by articular cartilage. It is received into the incisura ulnaris of the radius, and round it the lower end of the radius is turned in the movements of pronation and supination. On its under aspect the head shows a pit near the root of the processus styloideus, to which the apex of the discus articularis or triangular fibro-cartilage, is attached. The remainder of the under surface is smooth, and articulates with the upper surface of this fibro-cartilage when the latter is moved together with the radius in pronation and supination.

The **processus styloideus** is a short somewhat pointed projection, which extends downwards on the inner and posterior aspect of the capitulum. It gives attachment to the internal lateral ligament of the wrist (ligamentum collaterale carpi ulnare). Posteriorly, a smooth shallow sulcus passes down-

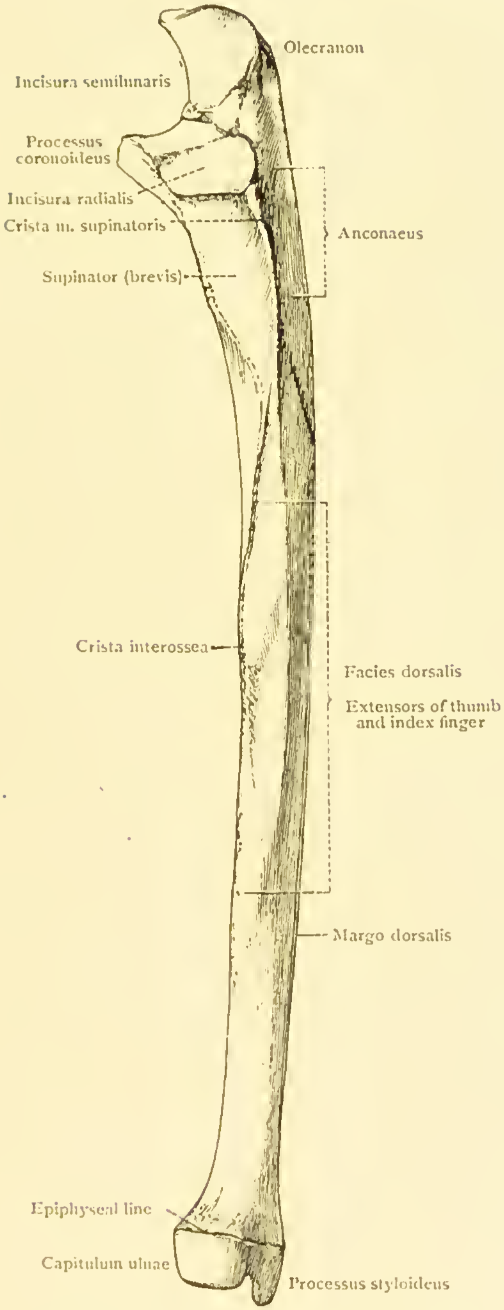

FIG. 40.—Left ulna from the outer side.

wards between the capitulum and the root of the processus styloideus, and during life transmits the tendon of the extensor carpi ulnaris muscle.

THE RADIUS.

The **radius** articulates at its upper end with the capitulum of the humerus, and also with the incisura radialis of the ulna; at its lower end it articulates with the upper surface of the carpus, and also with the capitulum ulnae.

The upper end of the bone is formed by a somewhat button-shaped head, or **capitulum**, which is smooth, articular, and slightly concave on its upper surface (**fovea capituli radii**) for articulation with the capitulum humeri. The vertical margin, or edge of the capitulum radii is also coated with cartilage, and articulates with the incisura radialis of the ulna and with the inside of the annular, or orbicular ligament, which holds the radius in its place. It will be noticed that the articular surface on the edge of the capitulum is better defined, deeper, and extends to a lower level on the inner than on the outer aspect of the head.

The head is supported by a short, almost cylindrical, **collum**, or neck, directed downwards and slightly inwards, and somewhat thicker above than below. The collum radii ends inferiorly at the level of a well-marked tuberosity, which is directed inwards towards the ulna, and affords insertion to the tendon of the powerful biceps muscle.

The tuberosity, or **tuberositas radii**, is smooth on its anterior part, over which lies a bursa beneath the biceps tendon, and rough posteriorly where the fibres of the tendon are inserted.

The shaft, or **corpus radii**, in its upper and outer part remains convex and cylindrical, but below the level of the tuberosity the inner part of the bone becomes compressed from before backwards, and a sharp inner edge, the **crista interossea**, is formed.

The cylindrical part of the shaft gives insertion to the supinator muscle, the lower limit of which is defined on the **facies volaris**, or anterior aspect of the bone by a line, known as the *anterior oblique line*. This begins above at the tuberosity, and runs downwards and outwards to end inferiorly at a rough mark on the outer aspect of the shaft about its middle point. Above, and to the outer side of the anterior oblique line, the surface of the radius is rounded and convex; below, and to the inner side, it is slightly hollowed out. The

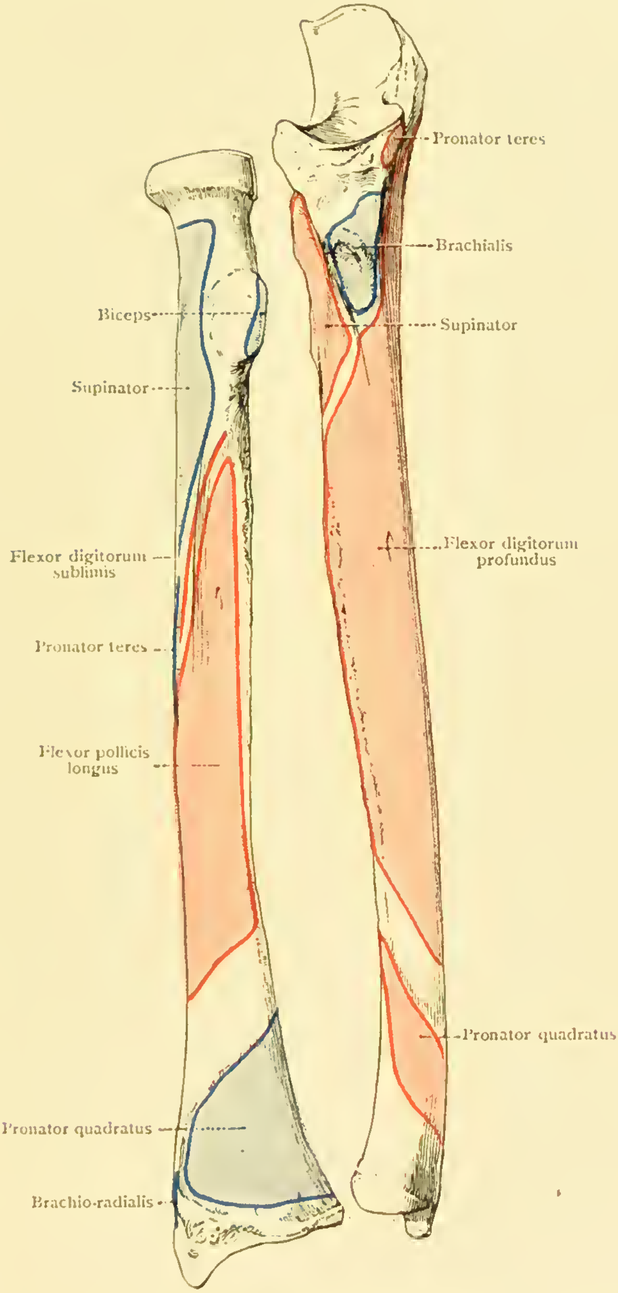

FIG. 41.—Right radius and ulna from in front, to show the attachment of muscles.

ridge gives origin to the radial head of the flexor digitorum sublimis, and the concave area below it to the flexor pollicis longus.

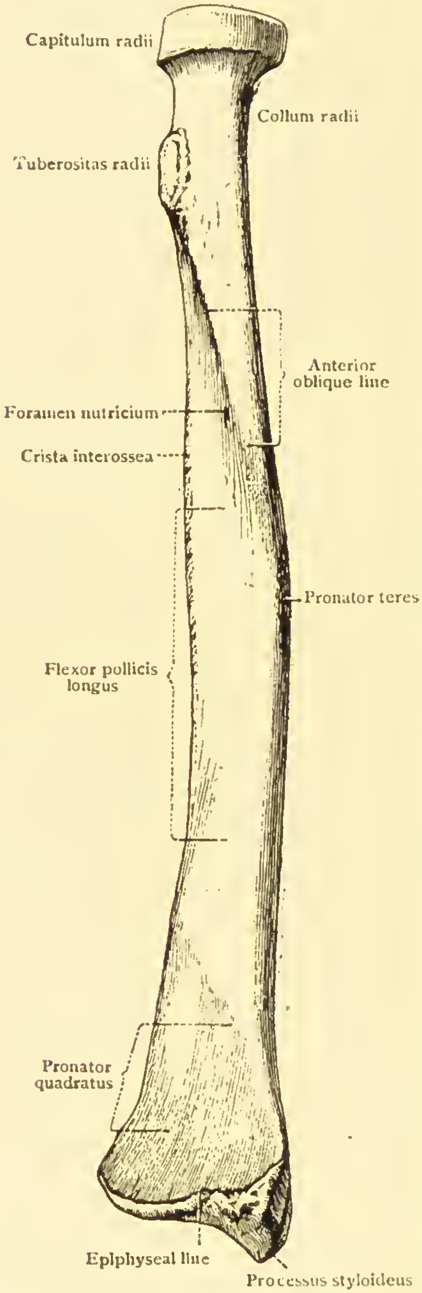

FIG. 42.—Left radius from in front: facies volaris. From a young subject.

The facies volaris of the radius becomes wider and flatter towards the lower end of the bone, and the lower fourth, or fifth, gives insertion to the pronator quadratus. A faintly-marked line, which runs obliquely downwards and outwards from the crista interossea towards the **processus styloideus**, sometimes indicates the upper limit of the attachment of the muscle.

The **foramen nutricium,** which is directed towards the upper end of the radius, lies on the facies volaris, just below the anterior oblique line.

The **facies dorsalis** of the radius is readily distinguished from the facies volaris by the fact that, unlike the latter, it is markedly convex from side to side in its lower part. In its upper part, the facies dorsalis is rounded and convex, and, like the corresponding area in front and to the outside of the bone, gives insertion to the supinator muscle. The abductor pollicis longus, or extensor ossis metacarpi pollicis, and the extensor pollicis brevis spring from the middle two-fourths of the facies dorsalis close to the crista interossea. The upper limit of the first-named muscle and the lower limit of the supinator is indicated by a *posterior oblique* *line*, running downwards and outwards towards a rough mark which occupies a position on the outer aspect of the shaft, about midway between the upper and lower extremities of the radius. This mark indicates the insertion of the tendon of the powerful pronator teres, and, as we have already seen, also indicates the lower limit of the anterior oblique line.

It will be noticed that the lower three-fourths of the shaft of the radius bends towards the outer side, and that the pronator teres is inserted into the summit of this outwardly-directed curve. In this manner the muscle obtains leverage in turning the radius into the prone position. In a somewhat similar manner the biceps muscle obtains leverage, and acts as a supinator, for it is inserted, as we have seen, into the tuberositas radii, which projects from the inner part of the bone, and occupies the summit of an inwardly-directed curve formed by the upper fourth of the radius. If a radius and ulna of the same side be carefully articulated, the significance of the curvatures of the radius as regards pronation and

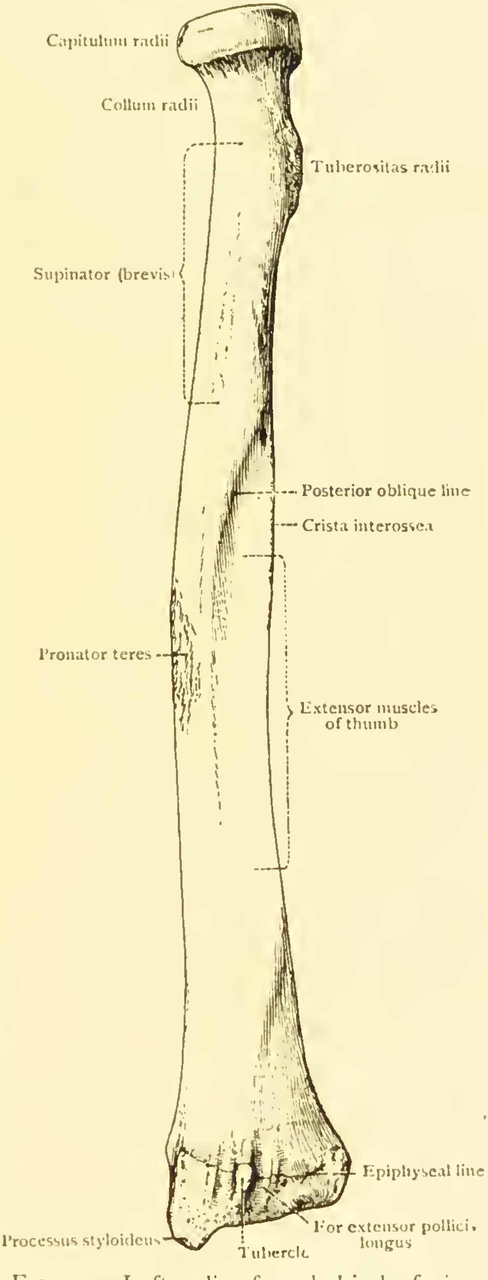

Fig. 43.—Left radius from behind: facies dorsalis. From a young subject.

supination will at once be apparent, when we bear in mind the attachment of the powerful muscles that produce these movements.

We have seen that the upper part of the radius is somewhat cylindrical, and circular in section; the middle part, on the contrary, is somewhat wedge-shaped in cross-section, the apex of the wedge corresponding to the sharp crista interossea, and the sides to the facies volaris and facies dorsalis. The base of the wedge is formed by the third surface of the radius, namely, the **facies lateralis**. This surface gives insertion in its upper half to the supinator muscle, and in its middle part to the pronator teres muscle, the rough attachment of which we have already noticed.

The borders which define the facies lateralis, namely, the **margo volaris** and **margo dorsalis**, separate it from the facies volaris and dorsalis respectively, and are for the most part rounded and indistinct, and quite unlike the sharp crista interossea which intervenes between the two latter surfaces. It should, however, be mentioned that the anterior oblique line is sometimes described as the upward continuation of the margo volaris, and that above it, the facies lateralis is regarded as turning forwards on to the anterior aspect of the bone.

The **crista interossea** becomes well marked a short distance below the tuberositas radii, and is thin, sharp, and rough for attachment of the membrana interossea. Inferiorly it divides into anterior and posterior ridges, which diverge as they descend, and at the lower end of the bone enclose between them a concave articular surface for the capitulum ulnae.

This surface, known as the **incisura ulnaris**, is oval in outline, its long axis lying in an antero-posterior plane. In the movements of pronation and supination this articular surface glides round the capitulum ulnae, against which it is firmly held by the triangular-shaped fibro-cartilage. The base of the fibro-cartilage is fixed to the lower border of the incisura ulnaris; the apex is, we have already seen, attached to the pit on the under-aspect of the ulna, close to the root of the processus styloideus.

The lower end of the radius is expanded, and is much wider from side to side than from before backwards. Its inner aspect is formed by the incisura ulnaris already described. Anteriorly, the flattened inferior end of the bone turns slightly forwards, and shows along its lower edge a somewhat raised, transversely placed, rough ridge for attachment of the ligamentum radio-carpeum volare, or anterior ligament of the wrist.

The posterior aspect of the lower end is arched, or convex,

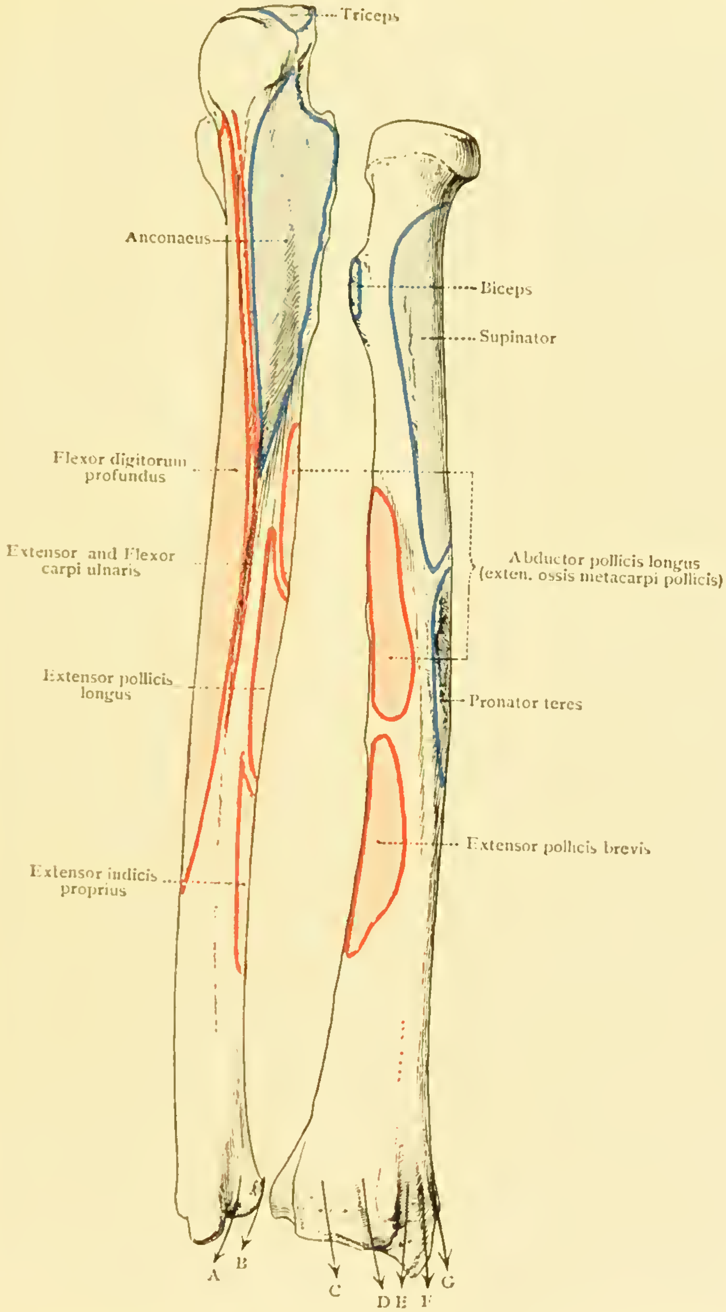

FIG. 44.—Right radius and ulna from behind, to show attachment of muscles and grooves for tendons at the wrist. A, extensor carpi ulnaris; B, extensor digiti quinti; C, extensor digitorum communis and extensor indicis; D, extensor pollicis longus; E and F, extensor carpi radialis longus and brevis; G, extensor pollicis brevis and abductor pollicis longus.

from side to side, and exhibits a series of grooves for the extensor tendons. These are arranged in the following order, from within outwards: first, there is a wide shallow sulcus, for the extensor digitorum communis and extensor indicis proprius; next, a narrow oblique groove, often deeply cut, for the extensor pollicis longus; and then a wide shallow groove for the extensor carpi radialis longus and brevis tendons. The oblique groove for the long extensor of the thumb has usually a high outer edge, which forms a distinct *tubercle*, round which the tendon pulls as it passes downwards and outwards towards the root of the thumb. This tubercle can be felt at the back of the wrist in the living subject, and, by extending the thumb, the extensor tendon and its oblique direction may be readily appreciated.

The outer aspect of the lower end of the radius is continued on to the outer aspect of the thick and short **processus styloideus**; it often shows a shallow sulcus (which may be subdivided), passing downwards and forwards for transmission of the tendons of the extensor pollicis brevis and abductor pollicis longus muscles. The outer surface of the lower end of the radius, just at the base of the processus styloideus, gives insertion to the tendon of the brachio-radialis muscle.

The **processus styloideus** of the radius is a thick, short, conical, downward projection from the outer part of the lower end of the bone. Its apex gives attachment to the ligamentum collaterale carpi radiale or external lateral ligament, and lies on a lower level than the apex of the corresponding process of the ulna.

The *under surface* of the radius is, for the most part, articular and covered with cartilage for articulation with the upper aspect of the carpus. The articular surface, or **facies articularis carpea**, is concave from before backwards, and extends laterally on to the inner aspect of the processus styloideus. It is subdivided into two facets, an outer approximately triangular, and an inner quadrilateral, the former articulating mainly with the os naviculare or scaphoid bone, the latter principally with the os lunatum (see fig. 45). The inner edge of the facet for the os lunatum gives attachment to the base of the triangular fibro-cartilage, and separates the incisura ulnaris from the surface for the carpal bones.

THE ELBOW ARTICULATION.

Having noted both the form and the markings of the humerus, ulna, and radius, the student is advised to obtain specimens of each from the same upper limb, and to study carefully the movements that take place at the elbow-joint, and also those which occur between the radius and ulna.

The strength of the elbow-joint depends to a great extent upon the interlocking of the humerus and ulna; the great deep incisura semilunaris closely embraces the trochlea of the humerus, and the projecting olecranon and processus coronoideus effectively prevent forward and backward dislocation. Indeed, so strong is the joint that dislocation forwards, or backwards, is scarcely possible without fracture of one or other of these projections.

The form of the trochlea, with its deep sulcus and prominent edges, renders dislocation inwards, or outwards, impossible, except as the result of severe violence.

The hinge-like movement of the ulna upon the humerus takes place in an oblique plane, the lower end of the ulna when flexed tending to come forwards and inwards; when extended, backwards and outwards. When the forearm is extended, the axis of the humerus forms an angle, which is open outwards, with the axis of the bones of the forearm; and so, when the arm hangs by the side, the inner part of the elbow comes into the hollow at the side of the waist.

It is important to note the varying position of the upper edge of the posterior surface of the olecranon in the movements of flexion and extension, as this part of the bone is so readily identified in the living subject, where it forms the 'point of the elbow'. In complete extension, when the beak-like projection of the olecranon fits into the fossa olecrani of the humerus, the 'point of the elbow' lies on a plane joining the epicondyles of the humerus, and midway between the epicondyles. In complete flexion of the joint, when the apex of the processus coronoideus is pressed home into the fossa coronoidea of the humerus, the 'point of the elbow' lies at the apex of an equilateral triangle, the lateral angles of which lie over the epicondyles.

When the elbow-joint is viewed from the inner side, it will easily be recognized that the point of attachment of the ligamentum collaterale ulnare to the internal epicondyle lies in the centre of the circle round which the ulna is moved. The two chief bundles of fibres composing the ligament correspond to radii of this circle, and hence are equally tight in all positions of the joint. They are attached, one to a rough mark on the inner side of the olecranon close to its upper and anterior part, and the other to the inner side of the coronoid near its upper edge. Similarly the fibres of the ligamentum collaterale radiale are disposed as radii of a circle, having its centre over the external epicondyle, and its circumference in the region of the ligamentum annulare radii, or orbicular ligament, into which the fibres are fixed. Hence these fibres also are tightly stretched in all positions of the elbow-joint.

The anterior and posterior ligaments of the elbow are thin, and alternately stretched and slackened in extension and flexion of the joint. They add little to the strength of the articulation.

The articulation of the radius with the humerus next demands our attention. The fovea on the summit of the capitulum of the radius is most accurately adapted to the convex surface of the humerus, when the forearm is in a position midway between flexion and extension. In flexion, when the capitulum of the radius is pressed against the fossa radii, the adaptation is by no means so complete; and in extreme extension of the forearm, the greater part of the capitulum humeri lies above the plane of the capitulum radii, and may be seen when the joint is viewed from in front. There are no ligaments passing from the humerus to the radius, and in this way the upper end of the latter bone is left free to turn inside the partly bony, partly ligamentous ring formed by the incisura radialis ulnae and the ligamentum annulare. The ligament which passes from the epicondylus lateralis, ends inferiorly, as we have seen, in the ligamentum annulare.

The student should note the plane of the humero-radial portion of the elbow-joint, and recognize how close it lies below the epicondylus lateralis when the forearm is extended. He should also practise the identification, in his own arm, of the capitulum radii in varying positions of the elbow-joint, and he should be able to appreciate its movement within the ligamentum annulare when the arm is pronated and supinated.

From his study of the articulation, it will have become evident that the elbow-joint consists of three parts, which are, however, anatomically continuous, and possess a single joint cavity; these subdivisions are termed humero-ulnar, humero-radial, and radio-ulnar.

THE RADIO-ULNAR ARTICULATIONS.

With regard to the movements of the radius upon the ulna, we have just seen that in pronation and supination the capitulum radii turns in the incisura radialis of the ulna, against which it is held by the ligamentum annulare. At its lower end, the radius is carried round the ulna, the capitulum ulnae lying against the incisura ulnaris of the radius.

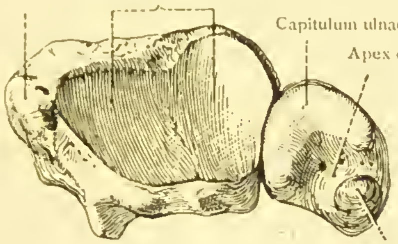

FIG. 45.—Lower ends of right radius and ulna from below; in supination.

At the lower, or distal radio-ulnar articulation, the most important connecting structure is the triangular fibro-cartilage, known as the discus articularis. Its apex lies at the centre of the circle in which the radius moves, and is fixed to the depression on the under surface of the ulna, near the root of the processus styloideus; its base is attached to the edge which

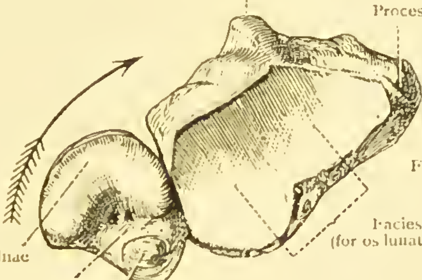

FIG. 46.—Lower ends of right radius and ulna from below; in pronation.

separates the facies articularis carpea, or carpal articular surface, from that of the incisura ulnaris of the radius. Its upper surface glides on the under aspect of the ulna when the radius moves. The cartilage may be regarded as a quadrant of a circle concentric with that in which the radius moves.

Since the lower end of the radius is carried round the capitulum ulnae, while the upper end merely rotates against the ulna, it will be obvious that in the movement of pronation the long axis of the radius describes a portion of a narrow cone, the base of which lies inferiorly, and the apex above, in the centre of the fovea capituli radii.

An examination of the interosseous space shows that its width varies during the movements of pronation and supination. This fact must be borne in mind when treating fractures of the bones of the forearm, in order to prevent vicious union of the bones across the interosseous space. The interval between the bones is widest in a position midway between pronation and supination. It will be found that if the palm of the hand is placed flat against the upper part of the opposite side of the chest, the forearm then is midway between pronation and supination.

In pronation, the radius lies obliquely across the ulna, its facies volaris being directed backwards, and its lower end lying to the inner side of the capitulum ulnae. In supination, the long axes of the two bones lie approximately parallel (compare figs. 47 and 41).

THE HAND.

The student should examine the hand of an articulated skeleton, and notice that it consists of a proximal part, or **carpus**, composed of a double row of somewhat cubical bones, the **ossa carpalia**; and a distal portion, or **metacarpus**, formed by five stout, somewhat cylindrical bones, the **ossa metacarpalia**, which lie immediately above and in the axes of the five fingers (see fig. 54). The bones of the metacarpus articulate proximally with the carpus, and distally with the proximal **phalanges** of the fingers. Each of the four inner fingers has a skeleton composed of three phalanges, named **prima, secunda,** and **tertia**; the thumb, however, possesses but two phalanges.

At a first glance the fingers appear to be of great length, and the hand proper of small size; this is because the corresponding metacarpal bone seems, in the skeleton, to be a part of the finger, and the carpus alone to represent the hand. If the student compares his own hand with that of the skeleton, he will readily recognize that the metacarpal bones really form the larger part of the hand, as distinct from the fingers, and that when the fingers are flexed towards the palm, the distal ends of the metacarpals are easily identified where they form the prominences of the knuckles.

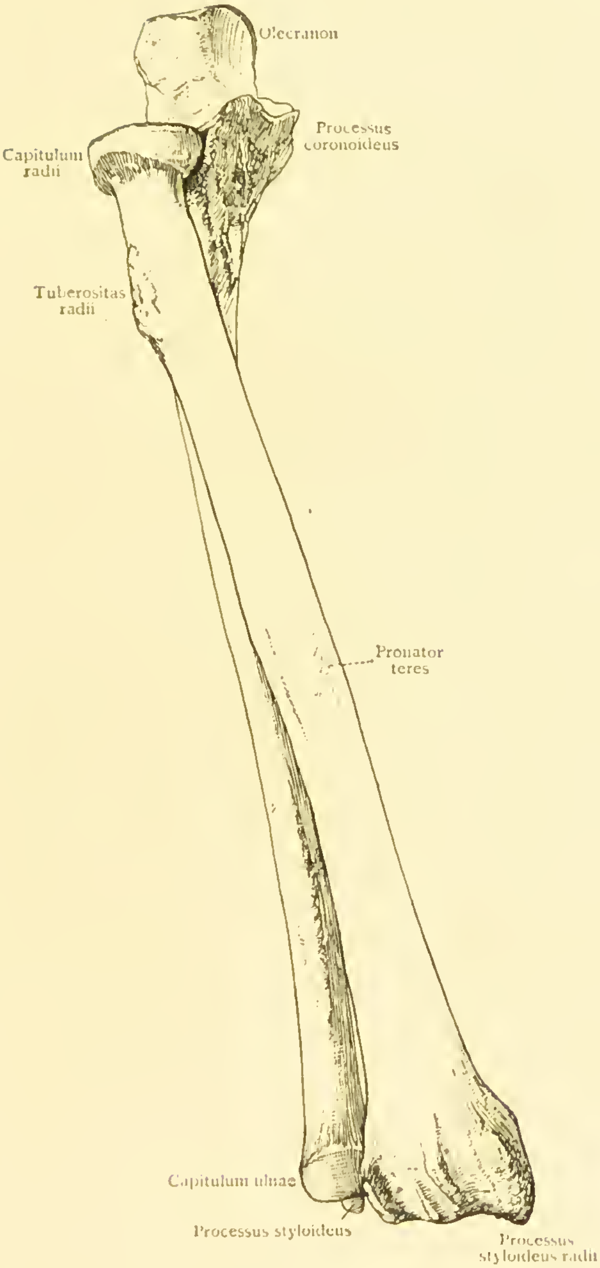

FIG. 47.—Bones of the right forearm in pronation.

THE CARPUS AND OSSA CARPALIA.

The **carpus** is arranged in two rows—proximal and distal—of four bones each. The bones of the proximal row are named, in order from the radial to the ulnar side:—**os naviculare, os lunatum, os triquetrum, os pisiforme**; those of the distal row are named in the same order:—**os multangulum majus, os multangulum minus, os capitatum, os hamatum.** The upper aspect of the proximal row articulates with the radius and the triangular fibro-cartilage of the wrist-joint; the lower aspect articulates with the upper surface of the distal row of bones. The lower aspect of the distal row articulates with the upper aspect of the metacarpus.

With the exception of the os pisiforme, each of the ossa carpalia has a dorsal non-articular surface which looks towards the back of the hand, and is connected by ligaments to the neighbouring bones. Also with the exception of the os triquetrum the volar, or palmar, aspect of each of these bones is non-articular and rough for the attachment of ligaments. It will be noticed that the os pisiforme lies in front of the os triquetrum, and that its dorsal surface articulates with the volar aspect of the os triquetrum. Viewed as a whole, the carpus is arched so as to be convex dorsally, and in agreement with this we find that, for the most part, the non-articular area of each of the bones is more extensive on the dorsal than on the volar, or palmar aspect.

If the student provide himself with a set of isolated carpal bones he will have little difficulty, while keeping the articulated hand before him, in identifying each bone, and in determining its position and articulations.

The **os naviculare**, or *scaphoid*, is the largest bone of the proximal row, and shows upon its upper aspect a triangular convex facet for the under aspect of the radius. This radial facet is separated by a narrow, depressed, rough area from another somewhat triangular, slightly convex area for articulation with the os multangulum majus and os multangulum minus. The facet for these latter bones lies on the radial side of the distal aspect of the os naviculare. On the ulnar side of the distal aspect is a deep concave facet for the head of the os capitatum. Between this concavity and the facet for the radius, is the narrow ulnar aspect of the bone, which is occupied by a crescentic articular area for the os lunatum. It is important that the student should recognize the **tuberculum ossis navicularis**, as it forms an important landmark in the wrist of the living subject, and gives part attachment to the radial end of the strong anterior annular ligament which binds down the flexor tendons, as they enter the palm of the hand. The tuberculum is a blunt conical process, which points forwards from the outer end of the rough region separating the articular area for the radius from that for the os multangulum majus.

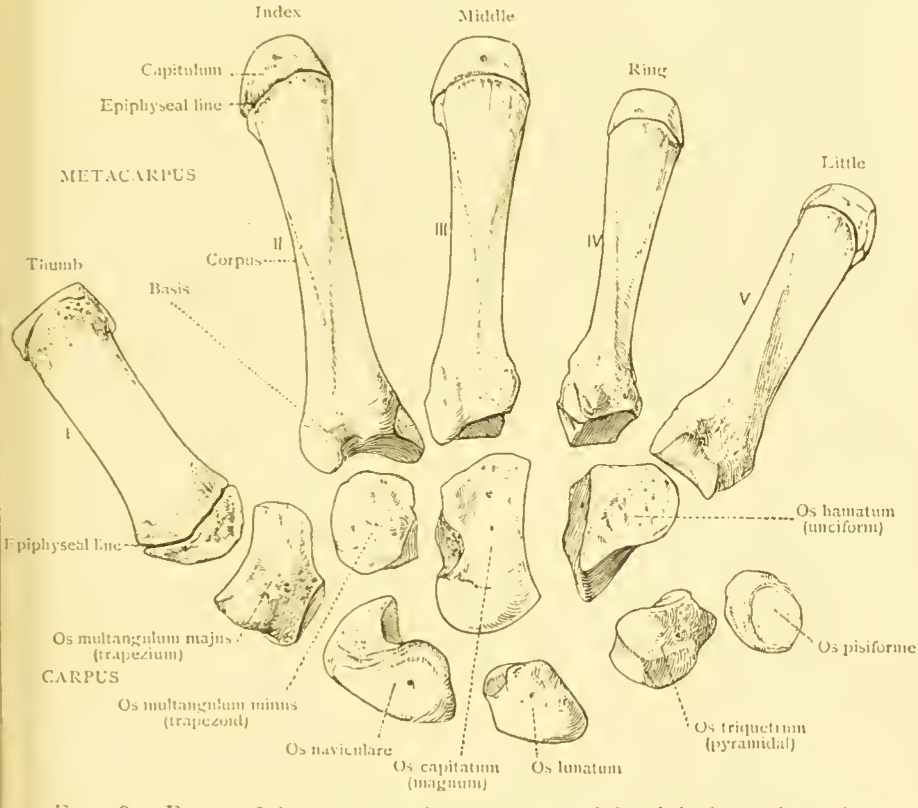

FIG. 48.—Bones of the carpus and metacarpus of the right hand from the dorsal aspect. From a young subject.

The **os lunatum** exhibits a crescentic outline when viewed from the ulnar or the radial aspect. The proximal surface is covered by a somewhat quadrilateral facet, convex from side to side and also from before backwards, for the radius. The distal surface is deeply concave from before backwards, and is subdivided into a large facet for the head of the os capitatum and a narrow area for the upper part of the os hamatum. The ulnar side of the bone possesses a flat quadrilateral facet for the os triquetrum, and the radial side a smaller crescentic facet for the os naviculare. It should be noticed that the dorsal rough area of the bone is less extensive than the volar, or palmar.

The **os triquetrum**, *cuneiform*, or *pyramidal*, is readily identified by the possession of a facet on its volar, or palmar, aspect. This facet articulates with the os pisiforme and is flat, and usually somewhat circular in outline. On its proximal aspect, the os triquetrum shows a small convex articular surface, often indistinctly marked, for the triangular fibro-cartilage of the wrist-joint. On its radial aspect there is a flat facet for the os lunatum, and its distal surface is occupied by an articular facet, which is slightly curved in a concavo-convex manner for articulation with the os hamatum.

The **os pisiforme**, the smallest of the carpal bones, is somewhat oval in outline, and about the size of a pea. It articulates with the os triquetrum by a smooth, nearly circular facet placed on its dorsal surface. It gives insertion to the flexor carpi ulnaris, and a part of the inner end of the anterior annular ligament is also attached to it. The os pisiforme is easily felt in the hand, and it can be made to slip from side to side over the os triquetrum. It forms a useful landmark, as the ulnar nerve and artery enter the palm of the hand immediately to its radial side.

The **os multangulum majus**, or *trapezium*, is most readily identified by the large, saddle-like facet, which it carries on the radial side of its distal aspect, for the base of the os metacarpale of the thumb. This facet is convex from side to side, and concave from before backwards. Proximally there is a slightly concave facet for the os naviculare; and on its ulnar side there is a facet for the os multangulum minus. Continuous with this latter, and between it and the facet for the os metacarpale of the thumb, there is a small, nearly circular articular surface for the os metacarpale of the index finger. On the palmar surface of the os multangulum majus there is a ridge (**tuberculum ossis multanguli majoris**), which lies to the outside of, and overhangs, a narrow, deep sulcus for the tendon of the flexor carpi radialis muscle. This ridge affords attachment to fibres of the anterior annular ligament.

The **os multangulum minus**, or *trapezoid*, is, next to the os pisiforme, the smallest of the ossa carpalia. It has a relatively large dorsal, and a small volar, rough surface. Its proximal aspect articulates with the os naviculare, its distal with the base of the os metacarpale of the index finger. The former surface is quadrilateral and nearly flat, the latter is of irregular outline, convex from side to side and concave from before backwards. On its radial side, the os multangulum minus articulates with the os multangulum majus, and on its ulnar side with the os capitatum.

The **os capitatum**, or *os magnum*, is the largest of the bones which compose the carpus. Its upper, or proximal, end,

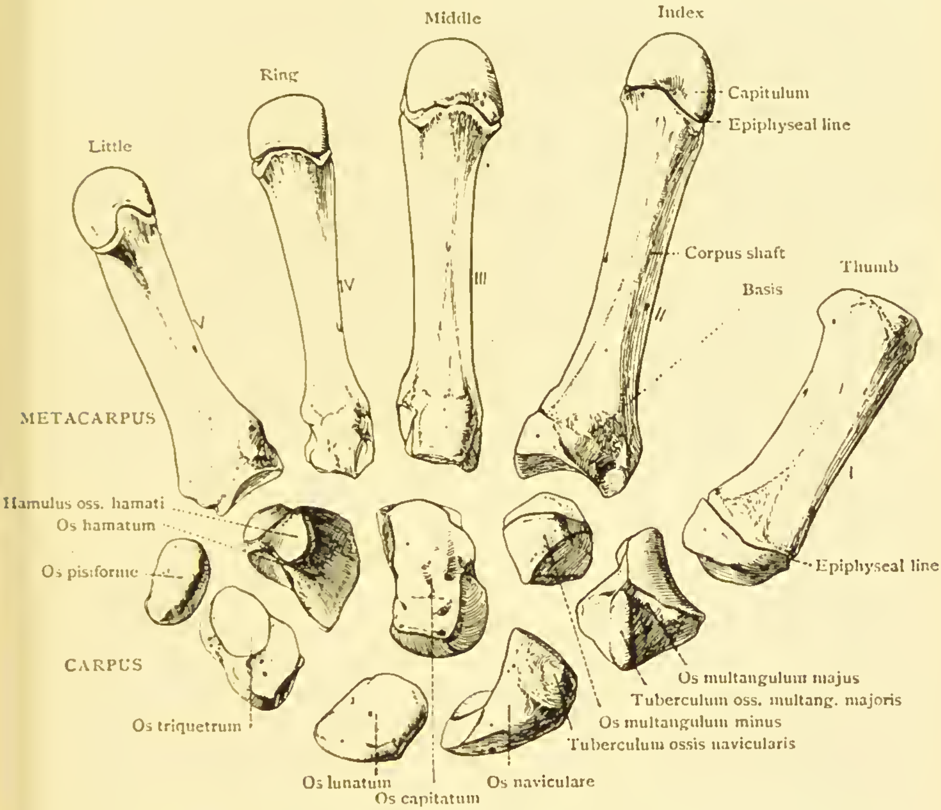

Fig. 49.—Bones of the carpus and metacarpus of the right hand from the volar or palmar aspect. From a young subject.

which may be regarded as the head of the bone, is received into a deep fossa formed by the under surface of the os lunatum. The articular surface for the os lunatum lies on the summit of the head, and is markedly convex from before backwards. The radial aspect of the head is also articular and convex; it is received into the deep concave facet of the os naviculare. The ulnar aspect of the head shows a flat facet for the os hamatum. The main portion of the bone, which lies below the head, articulates on its ulnar side with the os hamatum, and on its radial side with the os multangulum minus. The under, or distal, aspect of the os capitatum articulates with the bases of three ossa metacarpalia, and is subdivided into three facets. The middle, or largest, somewhat triangular in outline, is for the third (or middle) finger os metacarpale; the smallest is for the fourth (or ring) finger os metacarpale, and lies near the dorsal surface of the os capitatum; the third facet occupies a narrow district along the radial border of the under aspect of the os capitatum, and articulates with the base of the index finger os metacarpale. The dorsal surface of the os capitatum is flat and extensive, the volar aspect is smaller and raised to form a slight tubercle.

The **os hamatum**, or *unciform*, is, next to the os magnum, the largest of the ossa carpalia. It is readily recognized by the remarkable hook-like process, the **hamulus**, which projects forwards from its volar aspect, and gives attachment to the strong anterior annular ligament. Viewed from the dorsal aspect, the bone is somewhat triangular in outline. Its radial aspect is flattened, and articulates with the os capitatum; its distal aspect shows two facets—for the bases of the fourth and fifth ossa metacarpalia—and its proximal aspect shows a concavo-convex surface for the os triquetrum, and a narrow articular edge for the os lunatum.

THE CARPUS AS A WHOLE.

The student should next carefully articulate the bones of the upper or proximal row, and, holding them in position, note the common superior articular surface which they form. This surface is mainly formed by the os naviculare and the os lunatum; the os triquetrum shares in it only to a slight extent. The surface is convex from side to side, and also from before backwards, and articulates with the facets on the under surface of the radius, and also with the triangular fibro-cartilage. The amount of the common surface in contact with facets on the radius, and with the fibro-cartilage, varies with abduction and adduction of the wrist at the radio-carpal articulation. At this articulation, flexion, i. e. volar flexion, and extension, i. e. dorsi-flexion, as well as abduction or bending towards the radial side, and adduction or bending towards the ulnar side, take place.

If the student next examines the under aspect of the articulated bones of the first row, he will observe that the common articular surface is curved in a very remarkable manner. It shows a deep concavity, formed by the os naviculare and the os lunatum, into which the head of the os capitatum and the upper edge of the os hamatum are received. On the radial side of this concavity is a convex area formed by the os naviculare, for the os multangulum majus and os multangulum minus. On the ulnar side of the deep concavity there is a concavo-convex area, formed by the os triquetrum, for articulation with the os hamatum. The upper aspect of the lower, or distal row, is accurately adapted to this curved area. The joint formed between the upper and the lower row of bones is called the *transverse carpal articulation*; at it, volar and dorsi-flexion take place, and, to a far less degree, the movements of adduction and abduction.

Although the gliding movement between any two adjacent ossa carpalia is inconsiderable, the total effect of their mobility adds greatly to the flexibility and variability of movement in the hand. It is evident that a collection of slightly movable short bones firmly united by ligaments must form a very strong combination, and we are not therefore surprised to find that fracture of the carpal bones occurs very rarely.

It will be noticed that each row of carpal bones forms an arch which is concave from side to side on its anterior aspect. The pillars of the upper arch are the tuberculum of the os naviculare and the os pisiforme; those of the lower arch, the ridge, or tubercle of the os multangulum majus, and the hook-like hamulus of the os hamatum. The strong anterior annular ligament is tightly stretched between the pillars of the arch, and its presence adds much strength to the articulations. The hollow of the arch is occupied by the flexor tendons, as they enter the palm of the hand.

THE METACARPUS AND OSSA METACARPALIA.

The **ossa metacarpalia** are five in number, and are named first, second, third, fourth, and fifth in order from the thumb to the little finger. The thumb os metacarpale is free from the others, the upper ends of which lie close together, side by side, and articulate with one another. The bones diverge as they are traced downwards, and are separated by four interosseous spaces.

Each os metacarpale possesses a **corpus**, or shaft, a **capitulum** (head, or distal end), and a **basis**, or proximal end.

The first, or thumb os metacarpale is the shortest of the series, and the second, or index, the longest.

The ossa metacarpalia of the index, middle, ring, and little fingers resemble one another, although it is possible to identify each by the form of its basis and by the number and disposition of its articular facets. If the student carefully examine any one of these bones, he will readily observe the following points:—

The **capitulum**, or *head*, is the widest part of the bone, and its smooth articular surface, which is convex from side to side, and also from before backwards, extends considerably further on to the volar than on to the dorsal aspect. The articular surface, which is wider on the volar than on the dorsal aspect of the capitulum, is continued further on each side than in the middle line of the bone, and forms on the volar aspect two small articular elevations separated by an intervening depression. The capitulum articulates with the base of the first phalanx, and also with the dense fibro-cartilaginous plate which closes in the volar aspect of the metacarpo-phalangeal joint. The sides of the capitulum are hollowed out, and each depressed area is bounded above and behind by a small, well-marked tubercle, to which is attached the strong collateral ligament (*ligamentum collaterale*) of the metacarpo-phalangeal joint. If the capitulum is viewed from the side, it will be noted that these lateral ligaments are attached behind the centre of the circle, the circumference of which corresponds to the outline of the articular surface. Hence it happens that the lateral ligaments are rendered tight, and resist abduction and adduction of the fingers, when the latter are firmly flexed towards the palm of the hand at the metacarpo-phalangeal joints. This fact may be readily demonstrated in the living hand.

The **corpus**, or shaft, of each os metacarpale is narrowest at a point a little above the middle point, and possesses dorsal, radial, and ulnar surfaces. The radial and ulnar surfaces meet together in front in a rounded border, which extends from the capitulum nearly to the base of the bone. These surfaces give origin to interossei muscles. The dorsal surface shows a flat area having the outline of an elongated triangle, upon which rest the extensor tendons of the finger. The pointed apex of the triangular area extends upwards, towards the base of the metacarpal bone, and the narrow base of the triangle lies near the capitulum, and corresponds to a line joining the little tubercles for the collateral ligaments. On each side of the triangular area the shaft gives origin to one of the dorsal interosseous muscles, except in the case of the ulnar side of the little finger os metacarpale. The palmar, or volar aspect of the bone is distinctly concave, and the dorsal aspect slightly convex, in its long axis.

The **basis** is expanded, and nearly as wide from side to side as the capitulum. Its upper aspect is articular for one or more bones of the distal row of the carpus. The sides of the

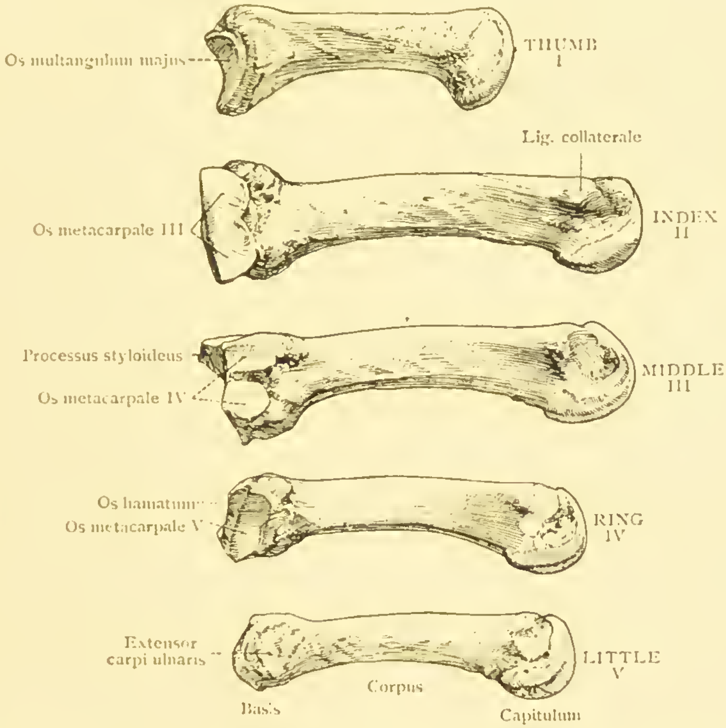

Fig. 50.—The ossa metacarpalia of the right hand, viewed from the ulnar side.

base articulate with the ossa metacarpalia with which it is in contact.

In order to identify the individual metacarpal bones, and to recognize the manner in which they articulate, it is necessary, in each case, to examine the form of the base and the arrangement of the articular facets which occur on it.

The *index*, or *second os metacarpale*, is the longest of the ossa metacarpalia. The upper aspect of the base shows a wide, deeply grooved articular facet for the os multangulum minus. As the groove runs from before backwards it gives the base a characteristically notched appearance when it is viewed from behind. On the radial edge of this groove the base exhibits a small, nearly circular facet for the os multangulum majus, and along the ulnar edge an elongated narrow facet for the os capitatum. The ulnar side of the base articulates with the os metacarpale of the middle finger. The rough posterior aspect of the base gives insertion to the tendons of the

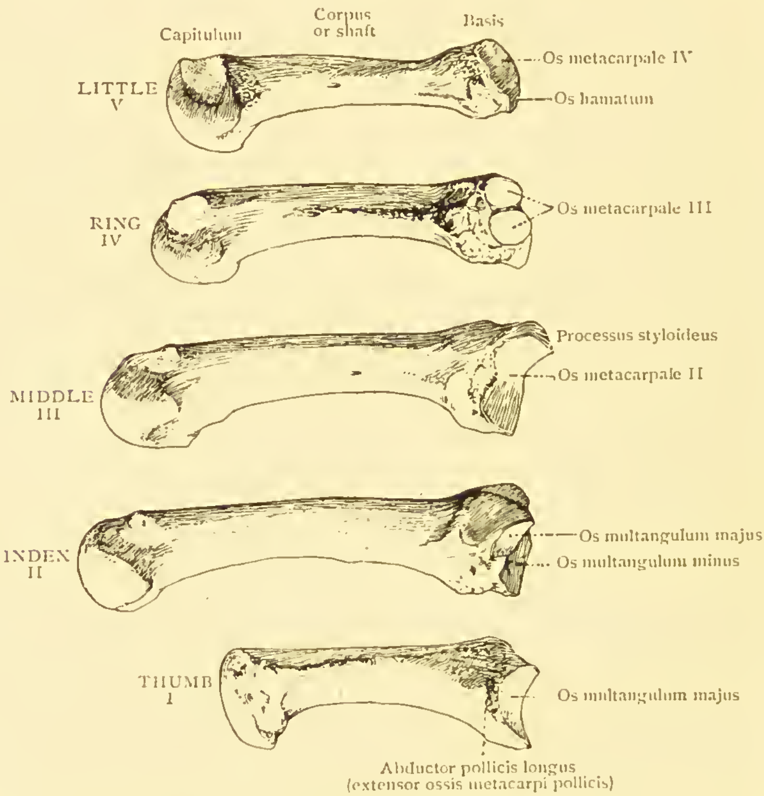

Fig. 51.—The ossa metacarpalia of the right hand, viewed from the radial side.

extensor carpi radialis longus and extensor carpi radialis brevis muscles; and to the rough volar aspect the tendon of the flexor carpi radialis is attached.

The *middle*, or *third os metacarpale*, is readily identified by the projecting **processus styloideus**, which springs from the outer and posterior angle of its base. This process can often be felt in the living hand, and is sometimes represented by a distinct ossicle. The dorsal surface of the bone in the region of, and below the processus styloideus, is rough, for the insertion of the extensor carpi radialis brevis tendon. The third os metacarpale articulates above with the middle of the three facets on the under surface of the os capitatum; externally with the base of the index finger os metacarpale; and internally, by two nearly circular facets, with the os metacarpale of the ring finger.

The *ring*, or *fourth os metacarpale*, is considerably smaller than either the second or third. Its base is small and narrow, and articulates above, chiefly with the os hamatum, and also by a small facet near its outer and posterior angle with the os capitatum. The radial side of the base shows an easily identified marking, in the two small raised circular facets, for articulation with the os metacarpale of the middle finger.

The *little*, or *fifth os metacarpale*, is still smaller in size than the fourth. The small narrow base has no articular facet on the ulnar side, but here we find a tubercle for insertion of the extensor carpi ulnaris tendon. On the upper surface of the base there is a facet for the os hamatum, and on the radial aspect a single facet for the fourth os metacarpale.

The *thumb*, or *first os metacarpale*, is shorter and stouter than the others. Its shaft, which is of nearly uniform thickness throughout its whole length, is wide from side to side and compressed from before backwards. The dorsal aspect is flat, and does not exhibit a triangular area similar to that found in the other ossa metacarpalia. The capitulum is wide from side to side; convex from before backwards, but not so from side to side. It articulates with the first phalanx of the thumb, and also with the two sesamoid bones. The base shows a saddle-shaped facet, convex from side to side and concave from before backwards, for the os multangulum majus. There are no facets on either the radial or ulnar aspect of the base, but its radial side shows an indistinct mark for the insertion of the abductor pollicis longus, or extensor ossis metacarpi pollicis, tendon.

CARPO-METACARPAL ARTICULATIONS.

It should be noticed that the joints between the four inner ossa metacarpalia and the distal row of the carpus are continuous, and that the bases of these ossa metacarpalia, when they are articulated, form a common undulating articular area which is accurately adapted for the under aspect of the carpus. The thumb os metacarpale, on the contrary, forms a joint with the os multangulum majus, which is isolated from the main carpo-metacarpal articulation.

The ossa metacarpalia do not lie in the same plane, but are so disposed that the metacarpus as a whole is concave from side to side on its anterior, or volar aspect.

The thumb os metacarpale possesses a greater freedom of movement than the others. It may be drawn (1) backwards and outwards, in extension; (2) forwards and inwards, in flexion; (3) outwards, in abduction; (4) inwards, in adduction; and (5) it can be rolled inwards so as to face the bone of the little finger as in opposition. Of the remaining ossa metacarpalia, that of the little finger alone possesses considerable freedom of movement. It can be drawn forwards in flexion; backwards in extension; and, to a slight extent, rolled outwards towards the thumb in opposition.

THE FINGERS.

The **phalanges** form the skeleton of the fingers, and are three in number for each digit, except the thumb, in which only two are present.

The phalanges are named (1) proximal, or **phalanx prima**; (2) middle, or **phalanx secunda**; and (3) distal, or **phalanx tertia.**

In each finger the **phalanx prima** is longer and stouter than either of the others, and slightly curved in its long axis. Its anterior, or palmar surface is flat, with well-defined borders which give attachment to the sheath for the flexor tendons. Its dorsal aspect is smooth, arched, and convex from side to side, and overlaid by the extensor tendons. In cross-section the outline of the shaft is semicircular.

The proximal end, or **basis,** of the phalanx prima is wider from side to side than from before backwards. It possesses a single concave oval facet, the longest diameter of which lies transversely. This facet articulates with the capitulum of the os metacarpale. On each side of the base is a slight roughness for the attachment of the collateral ligament of the metacarpo-phalangeal joint, and here also the interossei muscles are inserted.

The distal end, or **trochlea,** is not so wide as the base, and exhibits a pulley-like articular surface, convex from before backwards, and slightly concave from side to side, for articulation with the base of the phalanx secunda. The articular

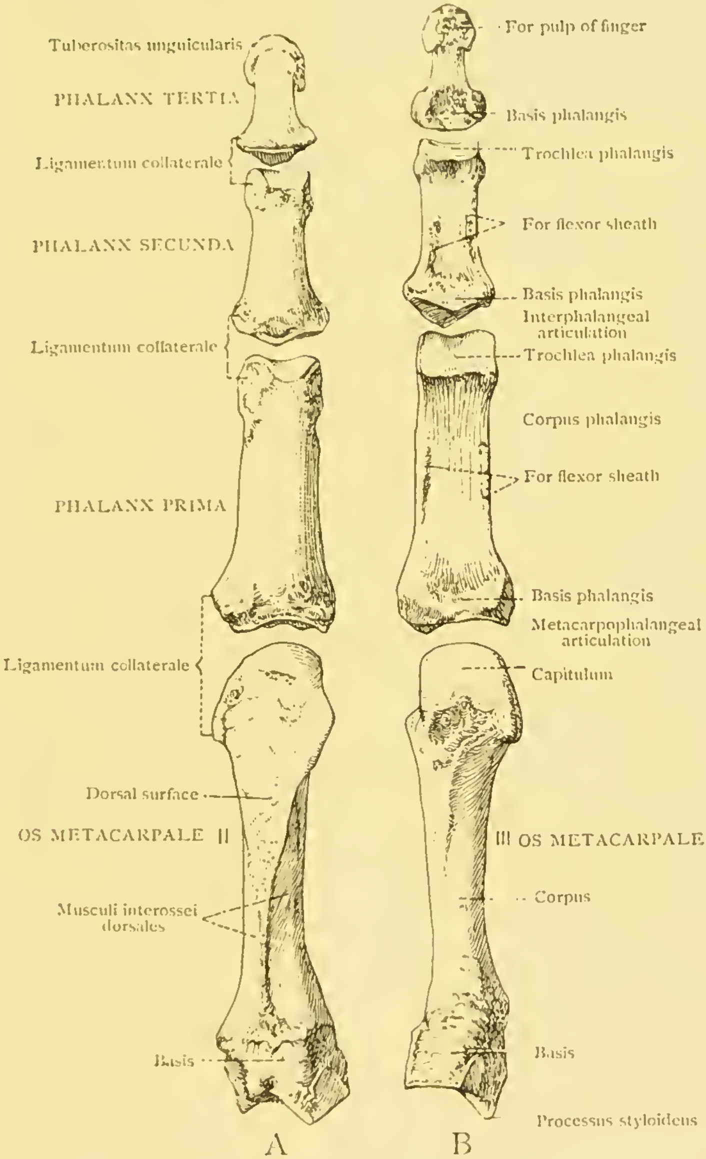

FIG. 52.—A, os metacarpale and phalanges of the right index finger, seen from dorsal aspect. B, os metacarpale and phalanges of the right middle finger seen from volar, or palmar aspect.

facet extends considerably more on to the palmar than on to the dorsal surface of the phalanx. The sides of the trochlea give attachment to the collateral interphalangeal ligaments.

The **phalanx secunda** is shorter than the phalanx prima, which it closely resembles except as regards the shape of its base. Like the latter, it has a flat anterior surface with distinct borders for the attachment of the flexor sheath; a smooth convex dorsal aspect; and a trochlear distal end. The base, however, does not, as in the phalanx prima, carry a single oval concave facet, but the articular surface has the form of two shallow smooth fossae, separated by a slightly marked articular antero-posterior ridge. These fossae are adapted to the raised edges of the trochlea of the phalanx prima, and the ridge fits into its grooved surface. The dorsal aspect of the base gives insertion to a part of the extensor digitorum communis, and its sides to the collateral interphalangeal ligaments. The anterior aspect of the shaft affords attachment on each side to a portion of the tendons of the flexor digitorum sublimis.

The **phalanx tertia** is of small size and compressed from before backwards. It is easily identified by the curious crescentic form of its distal end, known as the **tuberositas unguicularis**, which is flattened and rough anteriorly for the attachment of the pulp of the finger. The shaft is short and tapers as it reaches the expanded distal end. In form and appearance the base closely resembles that of the phalanx secunda, but it is smaller. The anterior aspect of the base is rough for the insertion of the flexor digitorum profundus tendon; the posterior part of the base affords attachment to a part of the extensor digitorum communis.

The two phalanges of the thumb resemble the phalanx prima and tertia of the fingers, but are stronger and stouter.

THE MOVEMENTS OF THE FINGERS.

In his own hand the student can readily study the movements which are permitted at the interphalangeal and the metacarpo-phalangeal articulations. At the joints between the phalanges, extension and flexion alone take place; the interphalangeal ligaments are so arranged that they are tight in all positions of the joints, and the articular surfaces are adapted for movement in one plane only. At the metacarpo-phalangeal joints, flexion, extension, abduction, adduction, and circumduction are permitted, the concave base of the phalanx prima gliding over the smooth capitulum of the os

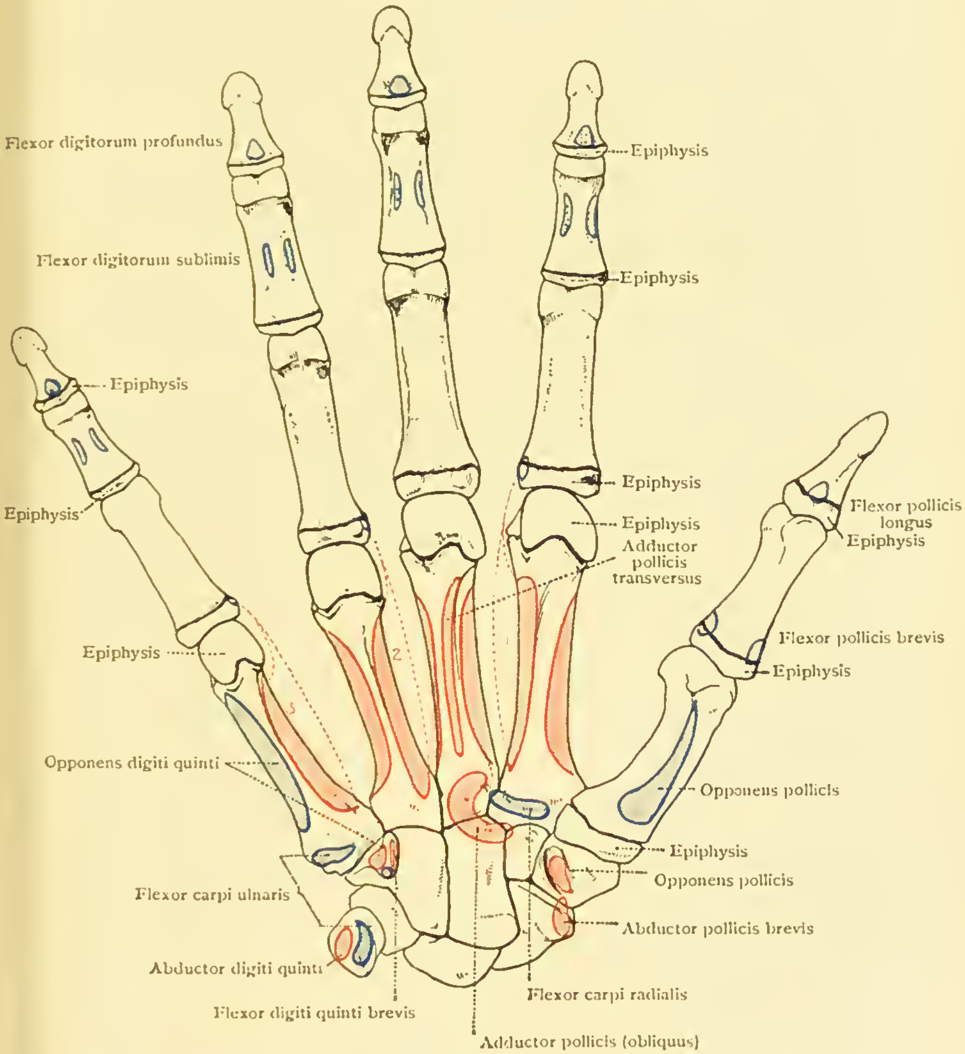

FIG. 53.—Right hand viewed from the volar or palmar aspect, showing the chief muscular attachments. The volar or palmar interossei muscles are indicated by the numbers 1, 2, 3 in red. Drawn from a young subject.

metacarpale. In circumduction, the finger as a whole is moved so that its tip describes a circle which forms the base of a cone whose apex lies at the capitulum ossis metacarpalis.

As we have already seen, the ligamenta collateralia of the metacarpo-phalangeal joints are on the stretch when the fingers

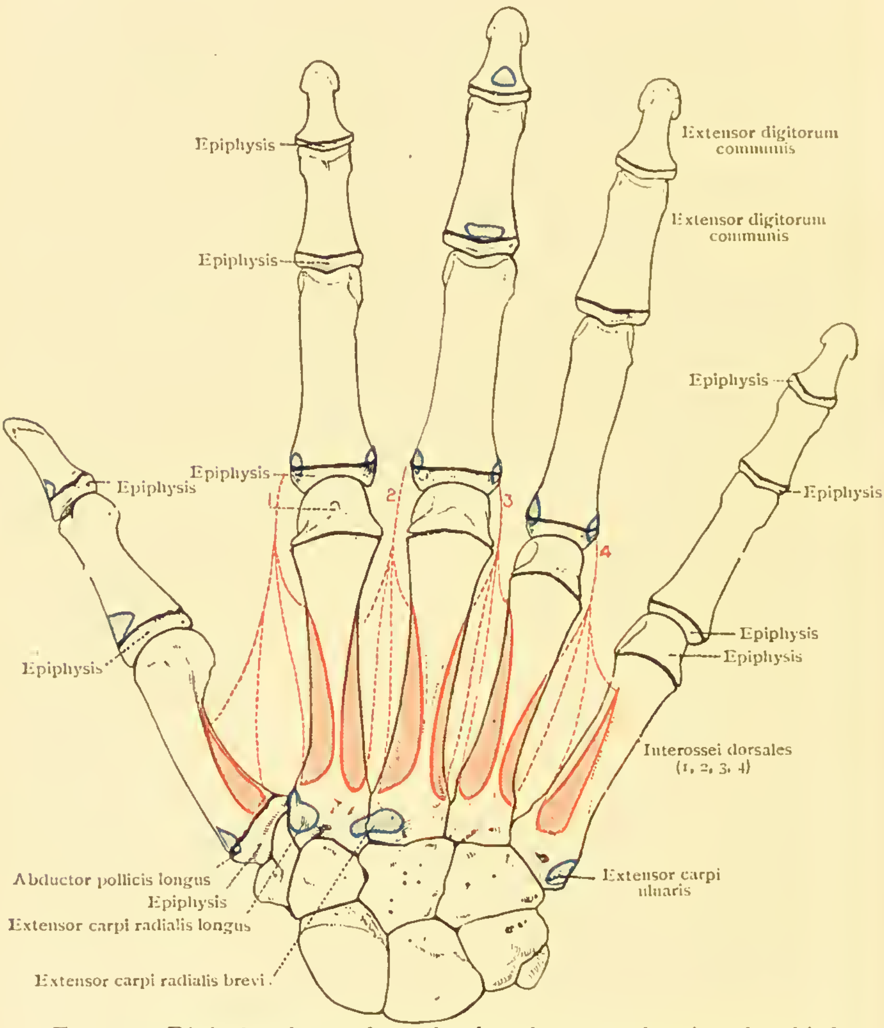

Fig. 54.—Right hand seen from the dorsal aspect, showing the chief muscular attachments. Drawn from a young subject.

are fully flexed towards the palm of the hand, and neither abduction nor adduction of the fingers is possible when they occupy this position.

THE LOWER LIMB.

An examination of the articulated skeleton shows that the free portion of the lower extremity articulates with the pelvic, or lower-limb girdle, and that in its strength and want of mobility the pelvic is in marked contrast with the shoulder-girdle. It will be seen that the *pelvic girdle* (**cingulum extremitatis inferioris**) is formed on each side by the flattened **os coxae**, or *innominate bone*, which is firmly united with its fellow of the opposite side at the middle line in front, and with os sacrum behind. This bone not only affords a firm basis of attachment and support for the lower limb, and assists in forming the wall of the abdominal cavity; but with its fellow of the opposite side and the sacrum, it encloses the pelvic cavity. Through the os coxae the weight of the body is transmitted to the lower limb.

THE OS COXAE.

It will be noticed that the **os coxae**, or *innominate bone*, is somewhat 8-shaped, the lower loop of the 8 surrounding a large foramen called the **foramen obturatum**, and the upper loop being closed and forming a thin expanded plate, the **os ilium**. On the outer aspect of the bone, just below the constriction which unites the upper and lower parts, there is a large, deep hemispherical fossa called the **acetabulum**, into which the head of the thigh-bone, or femur fits.

If the isolated bone be laid upon a flat surface, it will at once be apparent that the part above the acetabulum does not lie in the same plane as the rest of the bone, and that the os coxac as a whole is twisted upon itself in the region where it is constricted. The deep surface of the upper part looks forwards and inwards, that of the lower part backwards and inwards.

The os coxae, which in the adult forms a single massive bone, is in early life composed of three distinct bones united by cartilage. One of these, the expanded **os ilium**, lies superiorly; another joins its fellow of the opposite side at the middle line in front, and is called the **os pubis**; and the third, forming the lowest part of the bone, is named the **os ischii.** All three portions assist in forming the acetabulum. The foramen obturatum is bounded by the os pubis above and in front, and by the os ischii below and behind; the os ilium has no share in its formation. It is well, before undertaking a detailed examination of the adult bone, that the student should examine the os coxae of a young subject and note the lines along which fusion has occurred in the adult bone.

The **acetabulum** forms a deep cup-shaped cavity for the head of the femur, the opening of which looks outwards, downwards, and forwards. Its well-marked wall is deficient at one place, and there a deep notch, the **incisura acetabuli**, leads into the cavity. When the os coxae is placed in the position which it occupies in the living subject, the incisura acetabuli is in the lowest part of the wall of the cavity. The deepest part of the cavity, known as the **fossa acetabuli**, is non-articular, and during life is filled by a mass of fat. It is surrounded, except in its lowest part, by a horseshoe-shaped articular surface, known as the **facies lunata**, against which the head of the thigh-bone rests. The ends of the facies lunata reach as far as the edges of the incisura acetabuli, and the latter leads directly into the nonarticular fossa acetabuli. During life, the rough, sharp edge of the acetabulum gives attachment to a fibro-cartilaginous band, or ring—the labium glenoidale, or cotyloid ligament—which deepens the socket and diminishes the size of the outlet, embracing at the same time the caput femoris. The ligament is continued across the incisura acetabuli by the ligamentum transversum acetabuli, which is fixed to the anterior and posterior edges of the incisura acetabuli. Outside the line of attachment of the labium glenoidale, the capsule of the hip-joint is attached round the acetabular margin. A glance at a young bone, in which the three portions have not yet fully united, will show that the os ischii takes the largest, and the os pubis the smallest share in the formation of the acetabulum. Even in the adult the lines of union can usually be made out by a careful study of this region (see figures 55 and 57).

THE OS ILIUM.

The **os ilium** consists of a thick lower part, the **corpus ossis ilium**, which assists in the formation of the acetabulum, and of a thinner flattened upper part known as the **ala ossis ilium.**

The ala is somewhat fan-shaped, and forms about a quadrant of a circle. Its upper free convex border forms a thickened

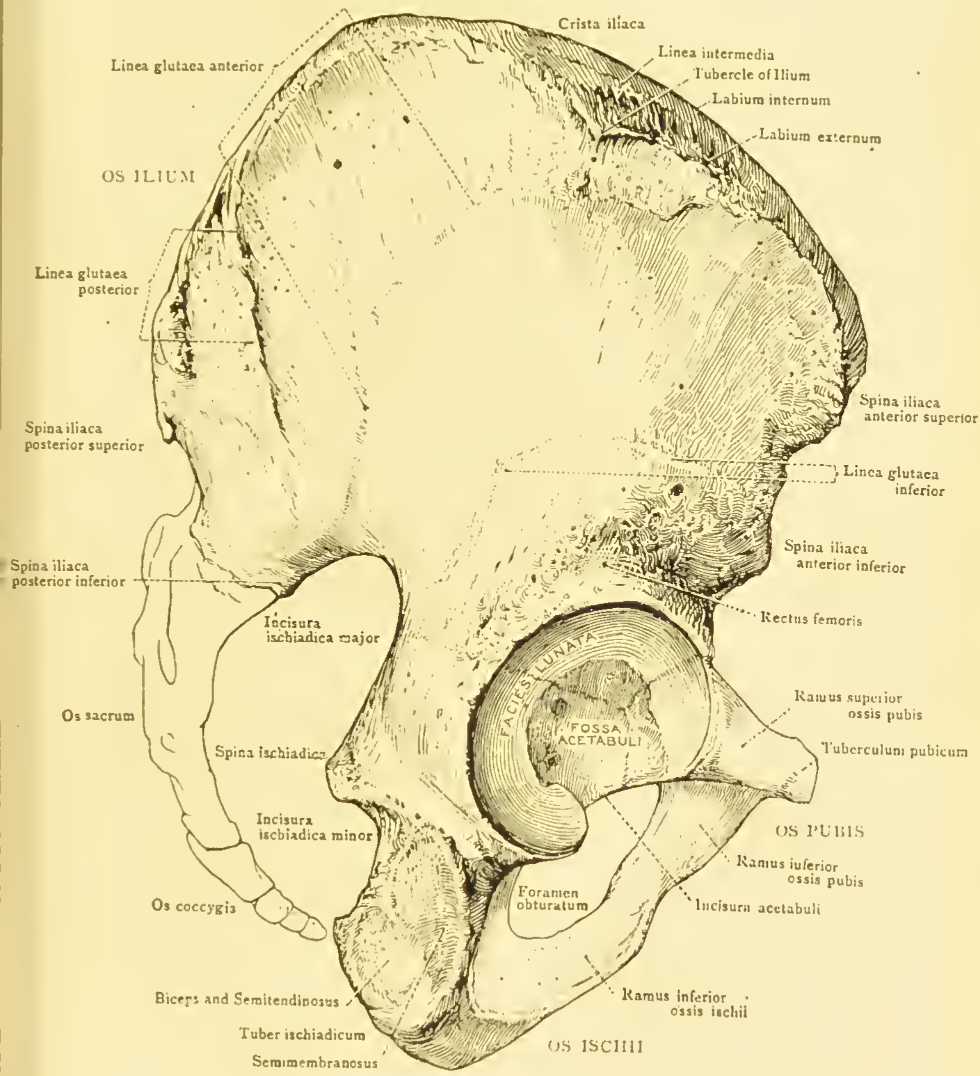

Fig. 55.—Os coxae of the right side seen from the outer aspect. From a male subject.

edge called the **crista iliaca**. This crest, which may be readily made out in the living subject, begins in front in a slightly overhanging process known as the **spina iliaca**

anterior superior, and, if its arched course be followed backwards, it will be found to end behind in a less clearly marked **spina iliaca posterior superior.**

If the crista iliaca be viewed from above it will be seen to be bent in a somewhat S-shaped manner, the anterior part forming a long curve which is convex outwards; the posterior part a short curve convex inwards. The anterior end of the crest is therefore directed slightly inwards; the posterior end a little outwards.

On the crista iliaca we can recognize an outer rough edge, or **labium externum**; an inner lip, or edge, usually less defined, the **labium internum**; and a rough intermediate part, the **linea intermedia.** These markings indicate the attachments of the three flat muscles of the abdominal wall, viz. obliquus abdominis externus (labium externum), transversus abdominis (labium internum), and the obliquus abdominis internus (linea intermedia).

The thickness of the crest varies much in different parts; a short distance behind the spina iliaca anterior superior it reaches its maximum, and here the labium externum bends outwards rather sharply and forms a slight elevation called the *tubercle of the ilium.* This tubercle forms an important landmark in the living subject, and a line connecting the tubercles of opposite sides corresponds with the greatest transverse diameter of the pelvic girdle.

The outer aspect, or *dorsum of the ilium*, is formed by a rough concavo-convex surface which gives origin to the great glutaeal muscles of the lower extremity. Three lines on the surface of the bone map out the areas of attachment of these muscles: (1) the **linea glutaea posterior**, or *superior curved line*, marks off what is usually the roughest part of the dorsum of the ilium, namely, a somewhat triangular area below and in front of the spina iliaca posterior superior, for the glutaeus maximus; (2) the **linea glutaea anterior**, or *middle curved line*, begins anteriorly in front of the tubercle of the ilium, and passes backwards and downwards in a curved direction, marking the lower limit of a somewhat sickle-shaped area for the glutaeus medius; (3) the **linea glutaea inferior**, or *inferior curved line*, usually less distinct, has an arched course, above and nearly parallel to the upper edge of the acetabulum. It indicates the lower limit of the attachment of the glutaeus minimus. Below the linea glutaea inferior and immediately above the margin of the acetabulum there is a rough depression which gives origin to the rectus femoris muscle (reflected head).

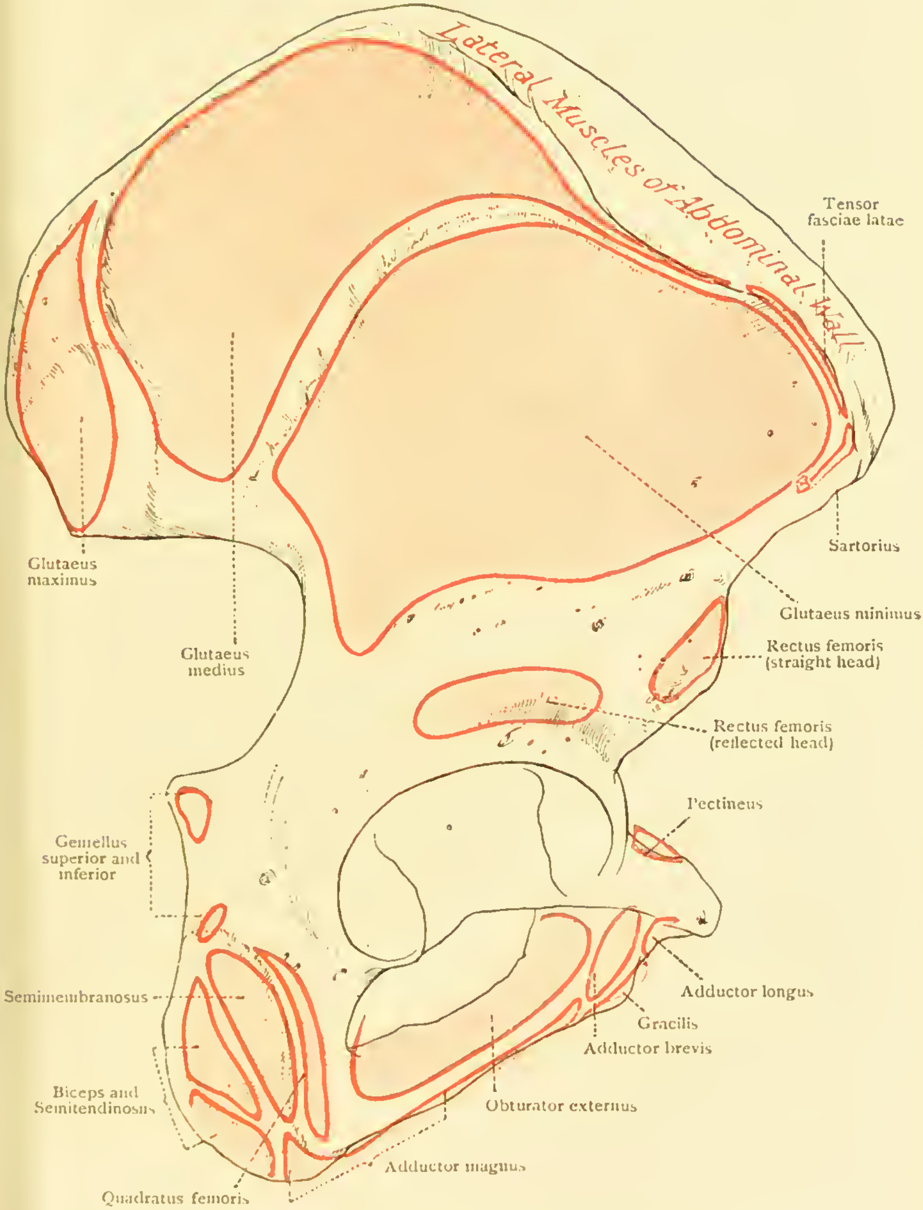

FIG. 56.—Os coxae seen from the outer aspect, to show attachment of muscles. From a female subject.

Before completing the study of the dorsum of the ilium, it is well to note its anterior and posterior borders.

The anterior border begins above at the spina iliaca anterior superior, from which it descends, forming a curve slightly concave backwards, to a low, thick, blunt projection, the **spina iliaca anterior inferior.** This latter process gives origin to the rectus femoris muscle (straight head), and lies a short distance above the margin of the acetabulum. The part of the anterior border immediately below the anterior superior spine gives origin to the sartorius.

The posterior border in its upper part is thin and sharp, and runs a nearly straight course for about one and a quarter inches from the posterior superior spine; then, becoming smooth and rounded, it suddenly changes its direction and dips forwards to form the upper boundary of a great notch called the **incisura ischiadica major**, or *great sciatic notch.* The angle formed by the change of direction of the posterior border at the upper limit of the notch is called the **spina iliaca posterior inferior.**

The deep, or inner aspect of the os ilium may be subdivided into (1) sacral, (2) abdominal, and (3) pelvic areas.

(1) The sacral area occupies the upper and posterior part, and on it may be recognized a conspicuous articular facet, known as the **facies auricularis**, for the lateral aspect of the sacrum. This facet is not quite flat but is slightly concavo-convex, and its outline is somewhat L-shaped. Above and behind the facies auricularis there is a rough area, **tuberositas iliaca,** for the attachment of the strong posterior sacro-iliac ligaments, and above this there is a rough district for the origin of fibres of the sacro-spinalis and multifidus muscles, and also for a part of the quadratus lumborum.

The abdominal and pelvic areas are separated by a smooth ridge which begins above at the anterior and lower part of the facies auricularis and runs downwards and forwards. It is known as the **linea arcuata**, and forms the **pars iliaca** of the **linea terminalis**, or *brim of the pelvis.* In the articulated skeleton it will be found to form a part of the boundary of the upper opening of the true pelvis or pelvis minor. Above and in front of the linea arcuata the deep surface of the ilium looks into the abdomen; below and behind this line it looks into the pelvis.

(2) The name **fossa iliaca** is applied to the surface of the bone which looks into the abdominal cavity. It is smooth and concave, and as a whole is directed upwards, inwards, and

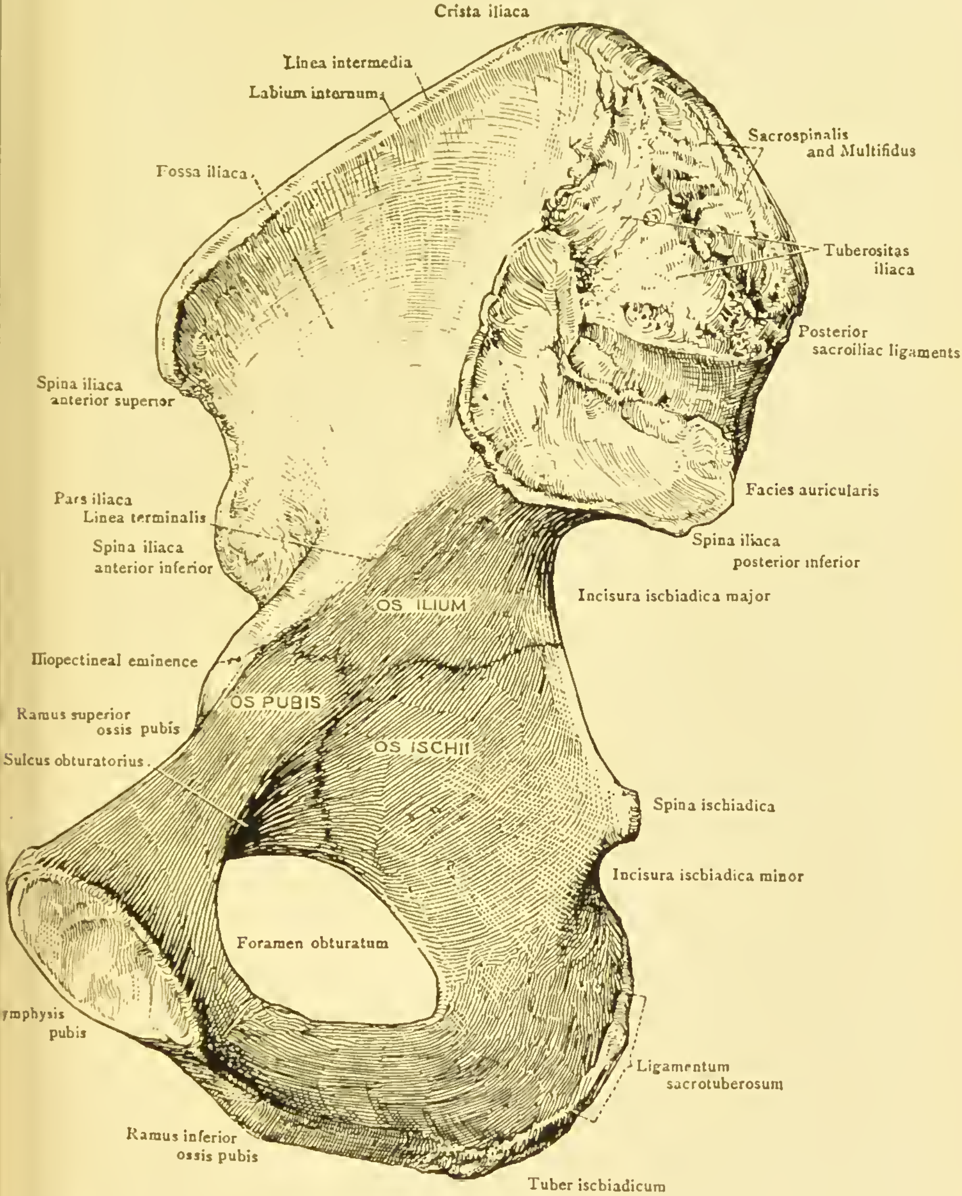

FIG. 57.—Right os coxae from the inner aspect.

forwards. The fossa iliaca is wide above where it is bounded by the labium internum of the crista iliaca, and narrows below where it is continued into a groove which passes downwards and forwards on the inner side of the spina iliaca anterior inferior. The fossa gives origin to the iliacus muscle and the groove transmits the common tendon of the psoas and iliacus muscles from the abdomen into the thigh. In the dry bone the groove is wide enough to lodge the index finger, and its inner boundary is formed by a slightly raised and rounded elevation known as the **eminentia ilio-pectinea,** or *ilio-pectineal eminence*, formed, as a glance at a young bone will show, partly by the os ilium and partly by the os pubis. The outer boundary of the groove is, as we have seen, the spina iliaca anterior inferior.

(3) The pelvic area lies below the linea arcuata and is flat; in the adult bone, it is continuous with similar areas formed by the os ischii and os pubis. It gives origin to a part of the obturator internus muscle. Very often, even in the adult bone, faint ridges may be seen on the pelvic surface of the os coxae, indicating the lines of fusion between the os ilium, os ischii, and os pubis (fig. 57).

It should be mentioned that the term *ilio-pectineal line* is often applied to the **linea arcuata** and its continuation, the **pecten ossis pubis**, described on page 118.

THE OS ISCHII.

The **os ischii** is the lowest part of the os coxae, and supports the weight of the body in the sitting posture. It forms rather more than two-fifths of the acetabulum, including the greater part of the non-articular fossa acetabuli.

The upper part of the bone, which takes part in the formation of the acetabulum and of its strong posterior wall, is known as the **corpus ossis ischii.** Its deep, or inner aspect, smooth and flat, looks into the cavity of the true pelvis, and gives origin to fibres of the obturator internus muscle. This surface of the bone is continuous with the pelvic surface of the os ilium and of the os pubis. Behind the acetabulum, the corpus ischii possesses a wide surface directed backwards and outwards, and bounded in front, by the margin of the acetabulum, and behind, by the posterior border of the bone where it forms the incisura ischiadica major. Over this surface pass the various structures which issue from the pelvis minor through the incisura ischiadica major.

It will be noticed that the lower limit of the **incisura ischiadica major** is formed by a well-marked triangular projection, known as the **spina ischiadica**, which gives attachment to the ligamentum sacro-spinosum, or lesser sacro-sciatic ligament.

Below the spina ischiadica is a shallower notch called the **incisura ischiadica minor**, the floor of which is smooth and articular. The tendon of the obturator internus as it leaves the pelvis minor winds over the smooth surface of this notch.

The incisura ischiadica minor is bounded inferiorly by a massive backward projection, the **tuber ischiadicum**, or tuberosity of the os ischii, which gives origin to an important group of muscles known as the hamstrings, and also affords attachment to the strong ligamentum sacro-tuberosum or great sacro-sciatic ligament. An oblique line subdivides the rough outer and posterior aspect of the tuber ischiadicum into two impressions—an upper and outer for the tendon of the semimembranosus, and a lower and inner for the common origin of the biceps and semi-tendinosus muscles. The outer edge of the tuber ischiadicum gives origin to the quadratus femoris, and its lower part to a portion of the adductor magnus muscle. The prominent rough inner edge of the tuber ischiadicum gives attachment to the ligamentum sacro-tuberosum, and forms the lower boundary of the smooth pelvic aspect of the os coxae.

The student will notice that between the upper and outer edge of the tuber ischiadicum and the lower and posterior part of the border of the acetabulum there is a groove, or depression, which affords space for the tendon of the obturator externus muscle.

The part of the ischium which lies below the spina ischiadica, and which bears the tuber ischiadicum on its posterior surface, is sometimes called the **ramus superior ossis ischii**. Superiorly it is not sharply defined, but is continuous with the corpus ossis ischii; below and in front, it is continued round the lower part of the foramen obturatum into the **ramus inferior ossis ischii**. The edge of each ramus, where it bounds the foramen obturatum, is thin and sharp and gives attachment to the membrana obturatoria. The ramus inferior is flattened and its lower margin is rolled outwards. It joins the ramus inferior of the os pubis and, in the adult bone, it is difficult to determine exactly the position of the line of union. The outer aspect of the ramus inferior ossis ischii gives origin to the obturator externus; the inner to the obturator internus muscle. The adductor magnus springs from the lower part of the outer surface, and the lower part of the inner aspect gives attachment to the crus penis and to the ischio-cavernosus muscle.

Before completing the study of the os ischii, the form, position, and size of the **incisura ischiadica major** should be carefully noted. It lies, as we have seen, between the spina iliaca posterior inferior and the spina ischiadica, and is formed partly by the os ilium, and partly by the os ischii.

During life, the incisura ischiadica major is mainly occupied by the musculus piriformis, but it also gives passage to a large number of other important structures, which include—the nervus ischiadicus or great sciatic, the nervus pudendus or internal pudic, the nerves for the glutaeal muscles, and the nervus cutaneus femoris posterior (small sciatic). The glutaeal arteries and the arteria pudenda interna (internal pudic) also pass through the incisura ischiadica major from the pelvis minor.

THE OS PUBIS.

The **os pubis** is the smallest of the three component bones of the os coxae, and, unlike the other portions, it reaches the middle line of the body where it becomes united with its fellow of the opposite side at the **symphysis ossium pubis**. An examination of the os coxae of a young subject shows that the os pubis forms about one-fifth of the acetabulum, and that in the acetabulum, it is joined with both the other parts of the os coxae.

We shall begin our examination of the os pubis by an investigation of the region near the symphysis.

The area, **facies symphyseos**, which is united to the bone of the opposite side, is usually smooth and flat, and has its long axis directed downwards and backwards. In outline it is an elongated oval, and it is longer in bones from male than in those from female subjects. At the symphysis the bones of opposite sides are very firmly united by a thick mass of fibro-cartilage.

The portion of the pubis which lies to the outer side of the symphysis, is usually described by British anatomists as the *body of the pubis*. It is a flattened mass of bone, prolonged into two diverging portions, called the rami of the pubis, which include between them the inner part of the foramen obturatum. The **ramus superior ossis pubis** passes upwards, outwards, and slightly backwards to reach the acetab-

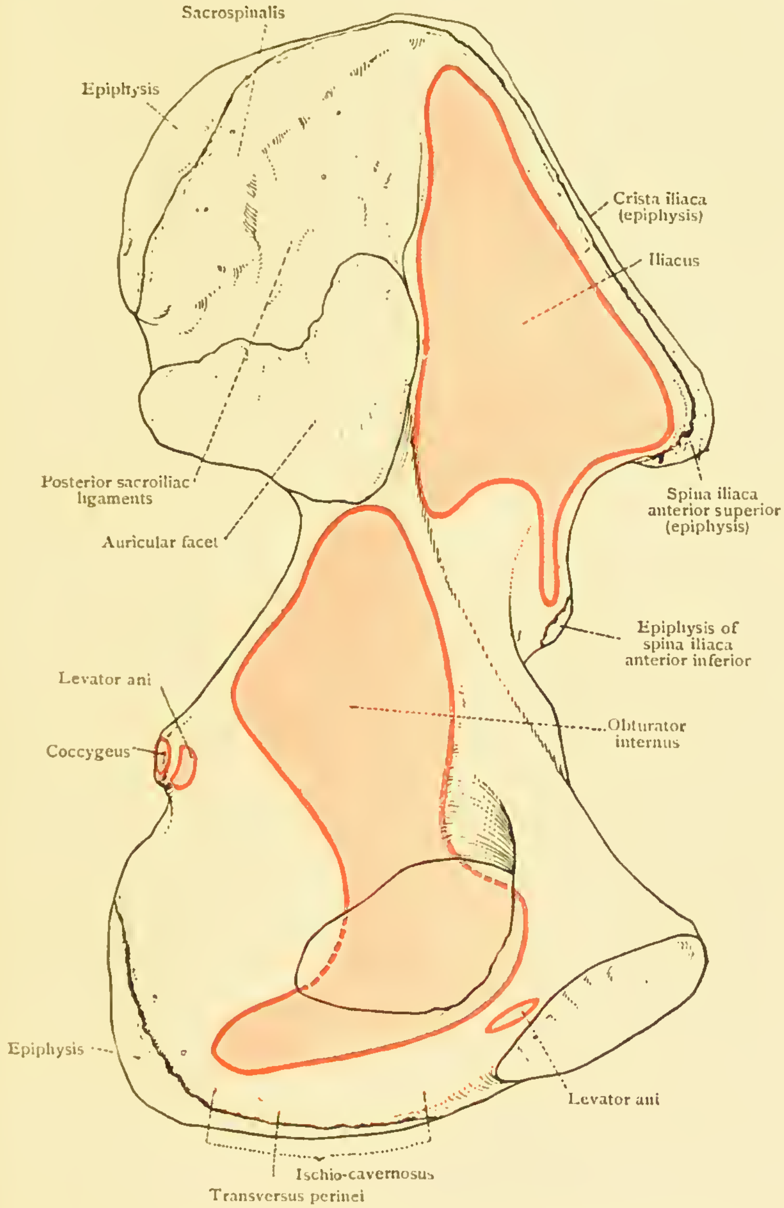

FIG. 58.—Left os coxae from the inner side, to show chief muscular attachments. From a young subject.

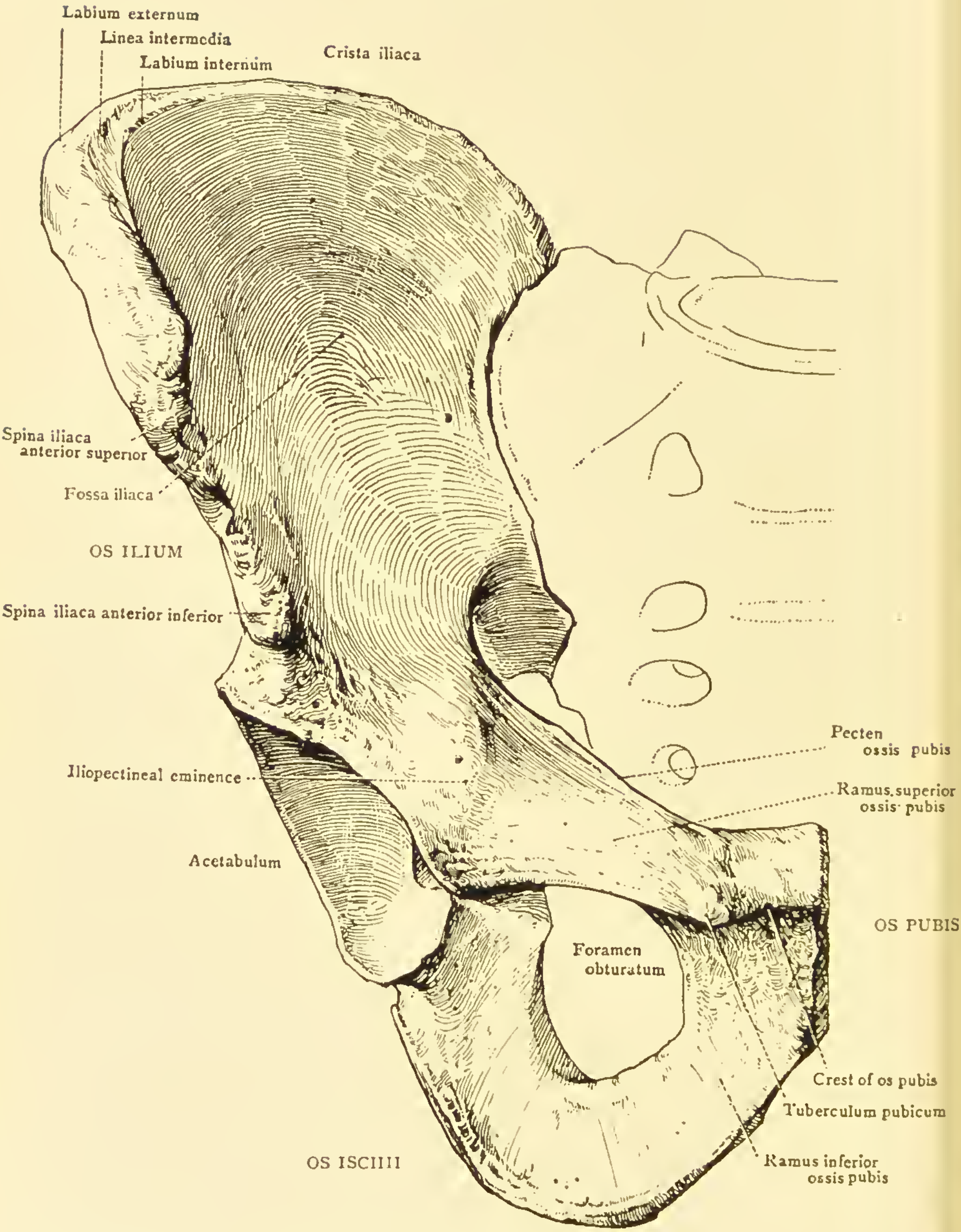

FIG. 59.—Right os coxae from in front.

ulum, where it joins the os ilium and os ischii; the **ramus inferior ossis pubis** passes downwards, outwards, and backwards, and becomes continuous with the ramus inferior ossis ischii. The deep surface of the *body of the pubis* is smooth and looks upwards and backwards into the cavity of the pelvis; it gives attachment to the levator ani muscle and to the pubo-prostatic ligaments. The superficial aspect looks downwards and forwards, and is rough for the attachment of a number of the muscles of the thigh, belonging to the adductor group. The more important muscles which spring from this part of the bone are, the adductor longus, adductor brevis, and adductor gracilis.

If the bone be viewed from in front, it will be noticed that a short ridge runs outwards from the upper edge of the symphysis to end externally in a slightly marked, somewhat conical tubercle. The ridge is spoken of as the *crest of the pubis* and gives attachment to the rectus abdominis and pyramidalis muscles. The tubercle in which it ends is known as the **tuberculum pubicum**, or *pubic spine*, and affords attachment to the inner end of the ligamentum inguinale, or Poupart's ligament. The term *pubic angle* is sometimes applied to the right angle formed at the point where the pubic crest meets the upper end of the pubic symphysis.

The **ramus inferior ossis pubis** is a flattened and compressed bar of bone, which passes downwards and outwards from the body of the os pubis to join the os ischium. Its superficial aspect gives origin to a part of the obturator externus, and also to portions of the adductor muscles. Its inner border is everted and gives attachment to part of the crus penis and to the ligamentum subpubicum; to its outer sharp edge is attached the membrana obturatoria. The deep aspect gives origin to the obturator internus, and near its inner edge, the crus penis and the sphincter muscle of the urethra are attached.

The **ramus superior ossis pubis** is a three-sided bar of bone, which passes upwards and outwards from the body of the pubis towards the acetabulum. It increases in thickness as it is traced outwards, and shows upper, posterior, and inferior surfaces. (1) The posterior surface is smooth, slightly concave, and looks into the cavity of the pelvis minor. (2) The upper surface, which is somewhat convex, looks upwards, forwards, and outwards, and is wide externally at the eminentia iliopectinea, where the os pubis joins the os ilium; and narrow internally in the region of the tuberculum pubicum. It is limited posteriorly by a well-defined ridge, **pecten ossis pubis**, which gives origin to the pectineus muscle and forms a part of the **linea terminalis**, or *brim of the pelvis* minor; anteriorly, it is bounded by a prominent rounded border, which extends

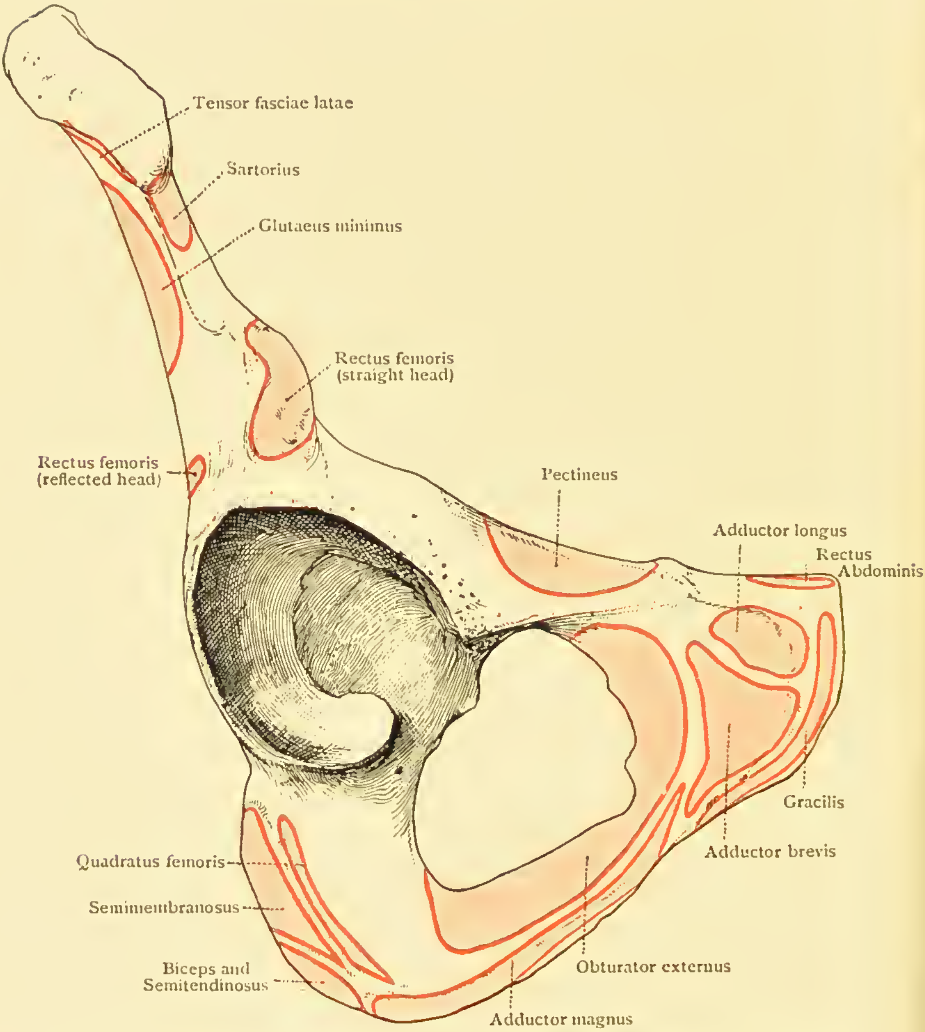

FIG. 60.—Right os coxae from in front, to show muscular attachments.

from the tuberculum pubis to the anterior margin of the incisura acetabuli. (3) The inferior surface of the ramus superior ossis pubis forms a groove which looks downwards into the upper part of the foramen obturatum, and is traversed during life by the obturator vessels and nerves. This groove, the

sulcus obturatorius, is directed obliquely downwards, inwards, and forwards, and, in order to see it, it will be found convenient to invert the bone, and examine the upper boundary of the foramen obturatum from below. When this is done it will be noticed that the anterior and posterior margins of the foramen obturatum do not meet, but that at the upper part of the foramen the continuation of the anterior edge passes deep to the continuation of the posterior edge. Between the two edges the sulcus obturatorius passes forwards. Sometimes a rough mark, or tubercle, may be seen on each of the boundaries of this sulcus for the attachments of a fibrous band which, crossing the groove, converts it into a foramen. This band at the same time forms the upper edge of the thin membrana obturatoria, which, during life, closes the foramen obturatum. The tubercles to which this band is attached are known as the **tuberculum obturatorium anterius** and **posterius**. The posterior tubercle which is situated in the region of the incisura acetabuli is often ill defined.

A comparison of a number of bones shows that the outline of the **foramen obturatum** varies very much, and that it may be roughly triangular, or oval, in outline.

Continental anatomists name the thick portion of the os pubis, which takes part in the formation of the acetabulum, the **corpus ossis pubis**. By the same writers, the ramus superior and the ramus inferior are described as uniting in the region named in this text the '*body of the pubis*'.

THE PELVIS.

The **pelvis** is formed by the right and left os coxae, the os sacrum, and the os coccygis. It should now be examined, and the differences which occur in this part of the skeleton in the two sexes should be carefully noted.

It will be readily recognized that in the pelvis we have to do with two subdivisions:—(1) an upper part which lies above the plane of the ilio-pectineal lines, and (2) a lower part which lies below this plane. The upper subdivision formed by the ossa iliaca and part of the basis ossis sacri, is known as the **pelvis major**, or *false pelvis*. It bounds the lower part of the abdominal cavity, and affords support to the abdominal viscera. The lower subdivision is known as the **pelvis minor**, or *true pelvis*. In it are situated the lower end of the alimentary canal, the urinary bladder, and in the female, the internal genital organs; in the case of the male a part of the genital apparatus.

The term *pelvic inlet*, or **apertura pelvis superior**, is applied to the upper opening of the pelvis minor; the term *pelvic outlet*, or **apertura pelvis inferior**, to the lower opening. The plane of the **apertura superior** is very oblique, and is inclined to the horizontal at an angle of about 50 to 60 degrees, in such a way that the opening leads downwards and backwards from the pelvis major into the pelvis minor. In studying the pelvis these facts should be borne in mind in order that the specimen may be held in the correct position.

The *brim of the pelvis*, or boundary of the apertura superior, is known as the **linea terminalis**, and consists on each side of a **pars sacralis, pars iliaca**, and **pars pubica**. The pars sacralis passes outwards on each side from the promontorium to the anterior edge of the sacro-iliac articulation, and forms the separation between the basis ossis sacri and the facies pelvina of the os sacrum. The pars iliaca is formed by the linea arcuata, and separates the fossa iliaca from the pelvic aspect of the ilium. The pars pubica is mainly formed by the pecten ossis pubis and the posterior part of the upper edge of the pubic bone close to the symphysis. The circumference of the superior aperture is greater in the female than in the male, and it will be noticed that in the male the aperture is encroached upon by the promontorium of the sacrum to a much greater degree than in the female.

It is very important to study the form, size, and inclination of the pelvic brim in the female skeleton. Special attention is paid to three diameters of the opening, namely, a transverse, an oblique, and an antero-posterior. The longest diameter is the *transverse*, and has an average length of $5\frac{1}{4}$ inches; the shortest is the *antero-posterior*, also called the *conjugate*, and measures $4\frac{1}{2}$ inches; the *oblique diameter* has an average length of 5 inches. The outline of the opening is oval. In the male pelvis all these diameters, especially the transverse, are smaller than in the female, and the outline of the opening is somewhat pointed anteriorly, and 'heart-shaped' owing to the forward projection of the promontorium.

The outline of the **apertura inferior** is very irregular. In the dry skeleton five bony projections will be seen to lie round the opening, namely, the tip of the os coccygis posteriorly, and the spina ischiadica and the tuber ischiadicum on each side; separating these are the incisura ischiadica major, and the incisura ischiadica minor, on each side, and the **angulus pubis**, or *subpubic angle*, in the middle line, in front. The latter

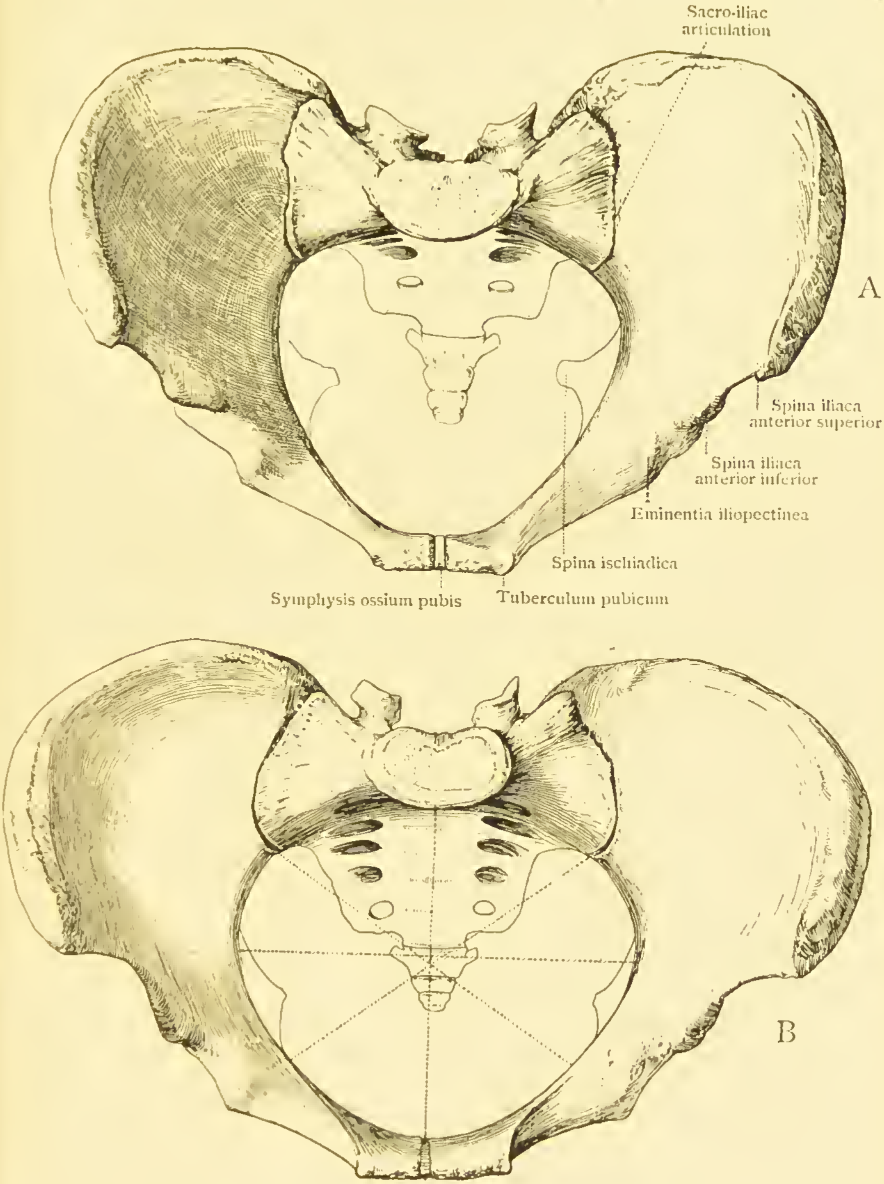

FIG. 61.—A, male, and B, female pelvis from above, to show the apertura pelvis superior or pelvic inlet. In B, the antero-posterior, oblique, and transverse diameters are indicated.

lies between the converging bony bars formed by the united rami of the os pubis and the os ischii. On each side of the os coccygis, a part of the boundary of the apertura inferior is formed, in the dry skeleton, by the lateral edge of the lower part of the os sacrum. In the living subject the boundary of the lower part of the pelvis is to a large extent formed by the ligamentum sacro-tuberosum and sacro-spinosum, or greater and smaller sacro-sciatic ligaments, which pass from the side of the os sacrum and os coccygis to the tuber ischiadicum and the spina ischiadica. These ligaments bridge across and convert the incisurae into foramina, known as the foramen ischiadicum majus and the foramen ischiadicum minus.

A comparison of male and female pelves will show that in the latter, the apertura inferior is larger than in the former. The tuber ischiadicum lies farther from the mesial plane, the spina ischiadica points less inwards, and the tip of the os coccygis is tilted less forwards in the female than in the male. In the female the arcus pubis is splayed, and encloses an angle greater than a right angle; in the male it is more pointed, and the contained angle is less than a right angle; also the incisura ischiadica is wider and more shallow in the female than in the male.

The cavity of the pelvis minor is bounded posteriorly by the facies pelvina of the os sacrum and os coccygis; on each side are the pelvic surfaces of the os ilium and os ischii; and anteriorly lies the pelvic surface of the os pubis. The cavity is shorter and more roomy in the female than in the male, and, in agreement with this, it will be noticed that the os sacrum is wider and shorter in the female. It should also be noted that in the female the pelvis as a whole weighs less, and the surfaces of the bones are smoother, than in the male; also the spina iliaca anterior superior and the crista iliaca lie further from the mesial plane in the female, as also does the tuberculum pubicum. In the female the length of the symphysis pubis is less than in the male. Within recent years attention has been called to the fact that the os ilium in the region of the facies auricularis shows marked sex characteristics; among these, are the smaller size of the articular surface and the greater depth of the sulcus for the ligamenta sacro-iliaca anteriora, which lies below and in front of this surface in the female. It would appear that the presence or absence of the latter characteristic is of great importance in determining the sex of the pelvis, or of the os coxae.

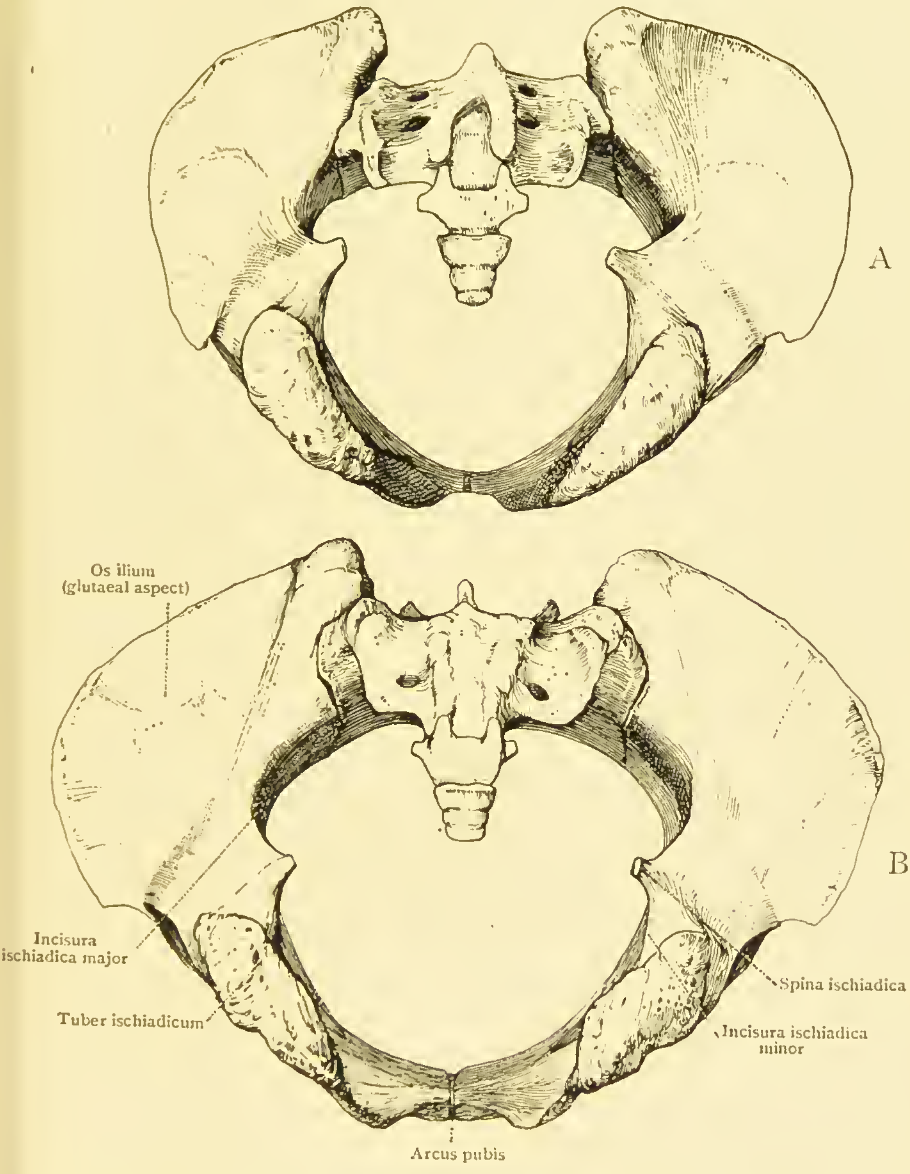

FIG. 62.—A, male, and B, female pelvis from below, to show the apertura pelvis inferior, or pelvic outlet.

THE THIGH-BONE, OR FEMUR.

The **femur**, or thigh-bone, is the longest bone of the body, and articulates superiorly with the os coxae, and inferiorly with the upper end of the tibia. In the articulated skeleton, it will be noticed that the bone lies obliquely, its upper end being separated from the femur of the opposite side by the width of the pelvic cavity; its lower end almost touching the bone of the opposite side in the middle line at the knee. In placing the isolated femur in its proper position, the student should be careful to adjust it so that the two articular prominences at the lower end, or *condyles*, lie on the same horizontal transverse plane. A comparison with the skeleton will show that when the under aspect of the lower end is made to rest evenly on the table, and the condyles occupy the same transverse plane, the femur tends to assume its proper position.

Holding the bone in its normal position, the student will recognize that the obliquity of the shaft is not only determined by the width of the pelvis, but is also dependent upon the direction assumed by the *neck* of the bone itself—the neck of the femur being directed outwards as well as downwards to join the shaft.

At the upper end of the bone, the smooth ball-like, articular **caput femoris**, or *head*, will be seen. It forms about two-thirds of a sphere, and during life occupies the deep socket of the acetabulum. A depression, or pit, called the **fovea capitis femoris**, will be noticed somewhat below the centre of the articular area of the head; to it the ligamentum teres is attached. This ligament contains but a small amount of ligamentous tissue, being mainly composed of synovial membrane, loose connective tissue, and a number of minute blood-vessels; the foramina, through which the latter enter the caput femoris, can usually be seen in the floor of the fovea. It will be noticed that the articular surface, which has a wavy edge, extends further over the head above and in front than below and behind.

The **collum femoris**, or *neck*, is directed from below, upwards, inwards, and slightly forwards; and forms with the shaft an angle of about 120°. The neck is somewhat compressed from before backwards, and is therefore oval in section. The tendon of the obturator externus muscle rests against its posterior aspect, and usually a very faintly-marked smooth groove on the neck, indicates the position of this tendon. The thin posterior part of the capsule of the hip-joint is

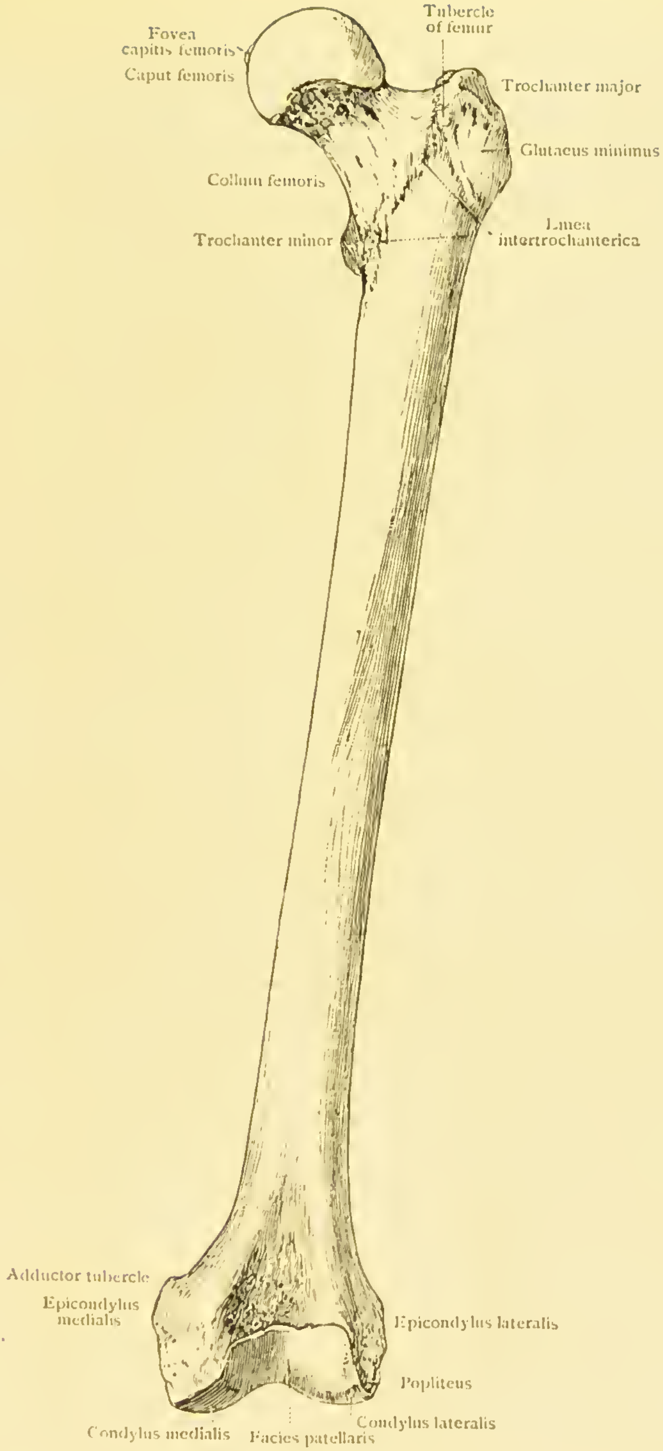

FIG. 63.—Left femur from in front.

attached to the posterior aspect of the collum femoris nearly one inch from the margin of the head, or about half-way down the neck. The anterior aspect of the neck lies within the capsule, which in front is attached to the junction of the neck and shaft.

In the region where the neck joins the shaft, two marked projections called trochanters afford leverage to the muscles which abduct and rotate the thigh. One of these, the **trochanter major**, forms the upward continuation of the outer part of the shaft; the other, the **trochanter minor**, is a conical process the apex of which is directed backwards and inwards.

The **trochanter minor** springs from the posterior and inner part of the upper end of the femur, and is attached at a lower level than the trochanter major. The tendon of the ilio-psoas muscle is inserted into the trochanter minor.

The **trochanter major** has an outer, somewhat quadrilateral surface on which may be seen an obliquely placed impression with its long axis directed downwards and forwards. This marks the insertion of the glutaeus medius muscle. The upper border of the trochanter major is free, and runs from before backwards, and slightly upwards. It affords insertion to a number of muscles, namely, pyriformis, gemellus superior, obturator internus, and gemellus inferior. The lower border is easily recognized, as it separates the smooth outer aspect of the shaft from the rough outer surface of the trochanter. It is rough, runs from before backwards, and gives origin to a part of the vastus lateralis muscle. The anterior aspect of the great trochanter presents an oval impression, with its long axis directed downwards and outwards, marking the insertion of the glutaeus minimus. The posterior border of the trochanter major is free and rounded, and, like the posterior part of the upper border, it overhangs the deep pit which occupies the free portion of the inner surface of the trochanter. This pit is known as the **fossa trochanterica**, or *digital fossa*, and gives insertion to the obturator externus tendon. The faint groove which crosses the posterior aspect of the collum femoris and which, as we have already noticed, indicates the position of the tendon of the obturator externus, leads to the fossa trochanterica.

The student should notice that the posterior border of the trochanter major is continued downwards and inwards as a smooth rounded ridge to the trochanter minor. This ridge is called the **crista intertrochanterica**, or *posterior intertrochanteric line*, and marks the lower limit of the collum femoris on the posterior aspect of the bone. The capsule of the joint is attached to the neck nearly one inch higher than the crista intertrochanterica. A slightly marked prominence

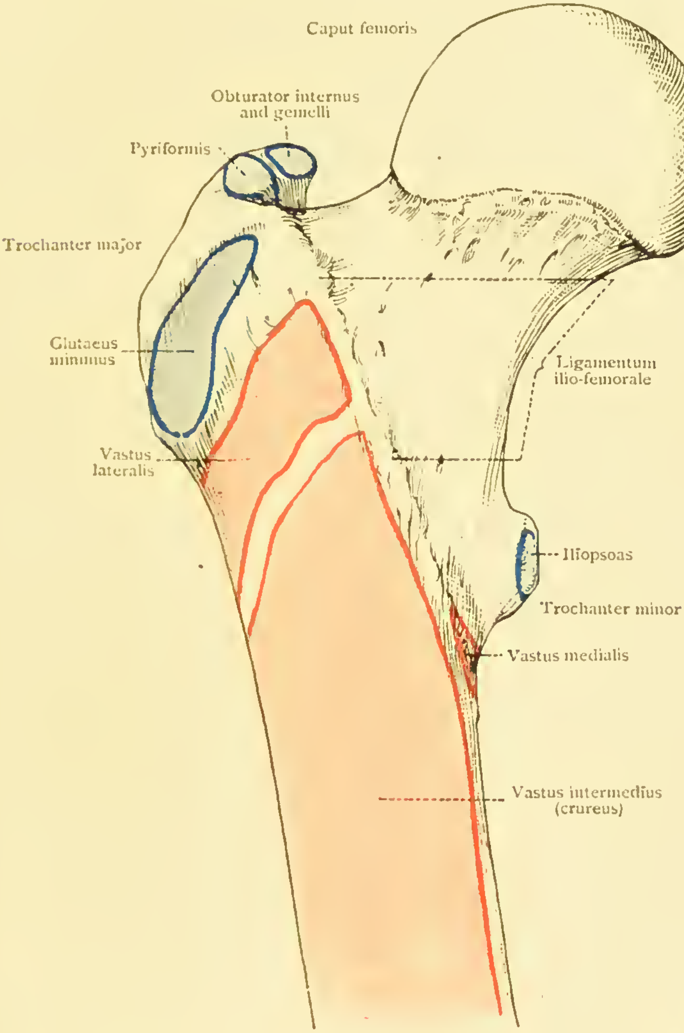

Fig. 64.—Upper end of right femur, showing muscular attachments.

called the *quadratus tubercle* may be recognized in the region where the crista intertrochanterica joins the posterior border of the trochanter major. The tubercle marks the upper limit of the attachment of the quadratus femoris muscle.

Next, by directing his attention to the anterior aspect of the bone, the student will find that the lower limit of the neck is indicated by a rough ridge which begins above, near the upper border of the trochanter major, and runs downwards and inwards in the direction of the trochanter minor. This ridge is called the **linea intertrochanterica**, or *anterior intertrochanteric line*, and serves for the attachment of the anterior part of the capsule of the hip-joint. It is usually most strongly marked near its upper and lower extremities where it gives attachment to the outer and inner bands of the strong ligamentum ilio-femorale, or Y-shaped ligament. The lower inner extremity of the ridge lies near to the anterior part of the trochanter minor, and here in some bones a prominent rough mark, often called the *inferior tubercle of the neck,* is present. This mark indicates the line of junction of the under aspect of the neck with the inner part of the shaft of the femur. The upper or outer end of the ridge is formed by a small tubercle, which points forwards and receives the name of *tubercle of the femur.*

The long *shaft* of the femur, or **corpus femoris**, when viewed from in front appears to be straight, but when looked at from the side, it is seen to be curved in its long axis so as to be slightly convex forwards in its lower three-fourths; and slightly concave in its upper fourth. It will be noticed that the femur is most slender in its middle part and that it expands below and, to a less extent, above. In its middle third, the posterior aspect of the shaft exhibits a prominent longitudinally directed ridge, or crest, known as the **linea aspera.** A transverse section through the middle of the femur exhibits a somewhat triangular outline with an acute angle directed backwards and corresponding to the linea aspera: the other angles are rounded. In agreement with this it will be found that the inner and outer surfaces of the shaft are sharply separated from one another along the linea aspera, and that each of these surfaces is continuous with the anterior aspect of the bone over a rounded border.

The **linea aspera** will be noticed to possess inner and outer edges which enclose between them a narrow rough area. These edges give attachment to the internal and external intermuscular septa of the thigh and are spoken of as **labium mediale** and **laterale**, or *inner* and *outer* lips, of the linea aspera. In front of the intermuscular septa, the edges of the linea aspera give origin to the fibres of the vastus lateralis and vastus medialis muscles. Behind the septa the linea aspera affords origin to the caput breve, or short head, of

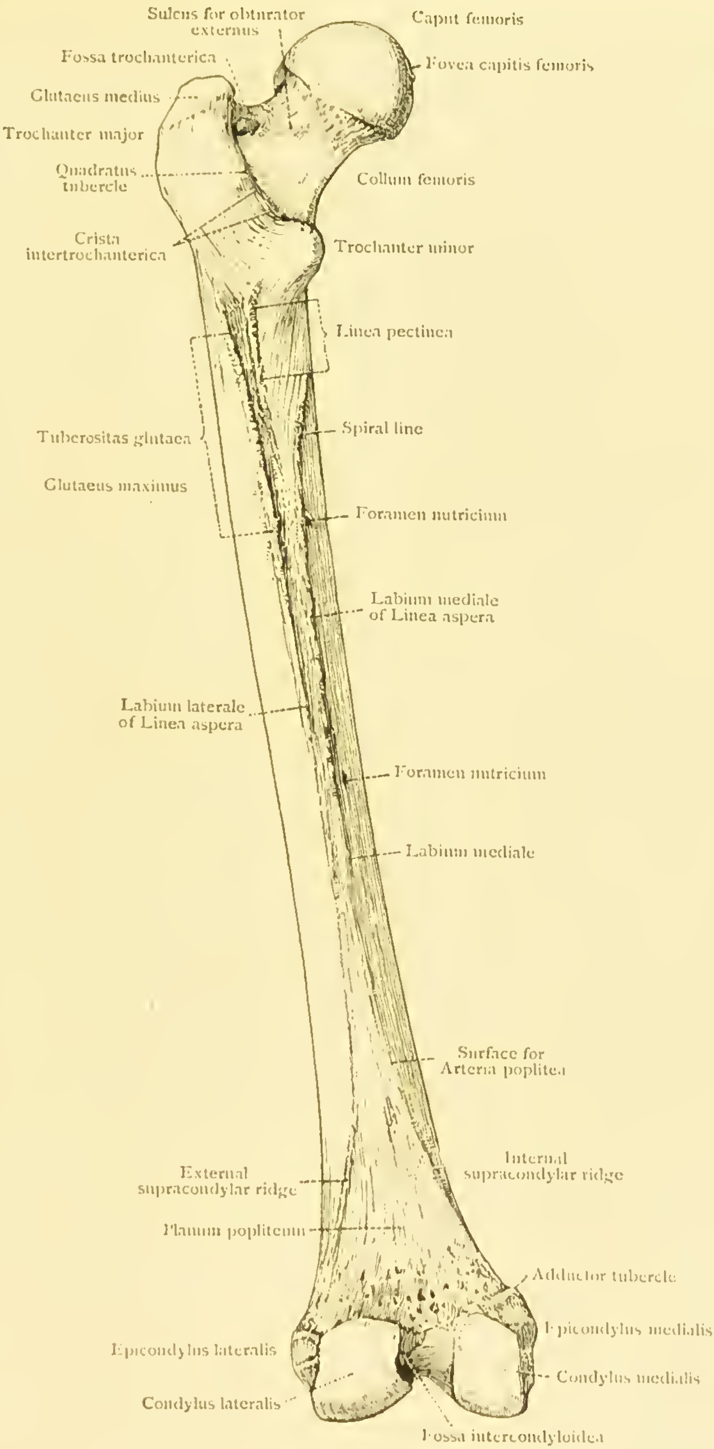

FIG. 65.—Left femur from behind.

the biceps, and insertion to the adductors, brevis, longus, and magnus.

The smooth anterior and lateral aspects of the shaft give origin to the vastus intermedius, or crureus muscle; the inner aspect is overlapped by the vastus medialis, but the greater part of this surface of the bone does not give attachment to muscular fibres.

In its upper third the shaft becomes somewhat wider from side to side, and slightly flattened from before backwards. The inner and outer surfaces are no longer sharply separated, and the anterior aspect is flattened and less convex from side to side. At the level of the trochanter minor the long axis of the bone is very slightly curved so as to present an anterior concavity. Attention has already been drawn to this curvature, which may be recognized if the bone is viewed from its inner, or outer aspect.

The linea aspera comes to an end at the junction of the middle and upper thirds of the shaft. Its labium mediale is continued upwards and gradually turns inwards, below, and in front of the trochanter minor, to join the linea intertrochanterica at the rough mark, where the under aspect of the neck is continuous with the shaft. This upward continuation of the labium mediale is known as the *spiral line of the femur* and marks the upper part of the origin of the vastus medialis muscle. The labium laterale in the upper third of the shaft is continued into a longitudinal rough ridge (sometimes a rough depression), which affords insertion to the glutaeus maximus muscle and is known as the **tuberositas glutaea.** In some cases this ridge, or its upper part, is so prominent that it is spoken of as a **trochanter tertius.** This trochanter occurs normally in some of the lower animals, such as the horse and rabbit. From the intermediate area of the linea aspera a faint line, the **linea pectinea**, which marks the insertion of the pectineus muscle, is continued upwards to the inner side of the tuberositas glutaea.

In its lower third the shaft of the femur becomes expanded, and loses its three-sided outline. The linea aspera divides, and its diverging limbs, known as the *supracondylar ridges*, enclose, as they are traced downwards, a smooth, flat, triangular surface, the **planum popliteum**, or *popliteal surface*, which lies on the back of the bone above the knee-joint. The planum popliteum forms the upper part of the floor of the popliteal space which lies at the back of the knee, and is in relation to the great artery (popliteal) which passes behind the knee-joint on its way to the leg.

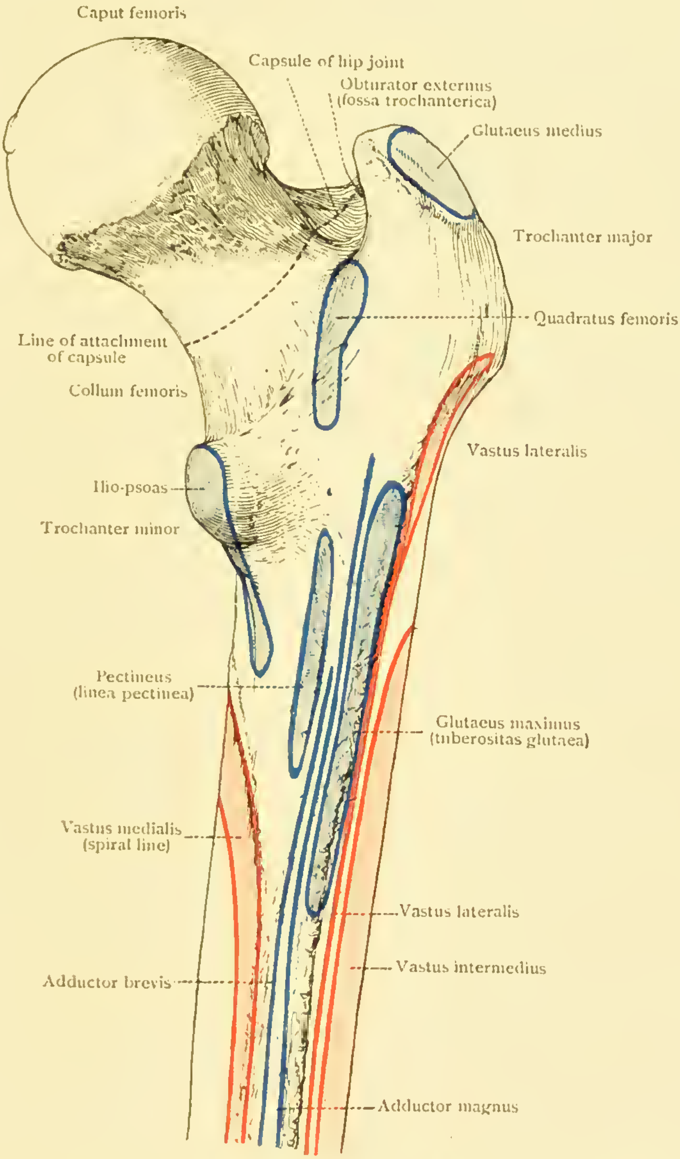

FIG. 66.—Upper end of right femur from behind, showing muscular attachments.

Of the two *supracondylar ridges* which bound the planum popliteum, the external is the better marked and gives origin in its upper part to the caput breve of the biceps muscle.

A careful examination of the internal supracondylar ridge shows that near its upper end it is but faintly marked, and that the planum popliteum in this region slopes gradually to join the inner surface of the shaft. It is in this position that the great artery passes from the inner side of the femur and comes to lie in relation to the planum popliteum. The inner supracondylar ridge gives insertion to the adductor magnus, and ends below at a slightly marked tubercle which lies immediately above the condylus medialis. This tubercle serves for the attachment of the tendon of the adductor magnus muscle, and, in spite of its small size, can be readily felt in the living subject by pressing into the hollow at the inner side of the knee immediately above the condylus medialis. The tubercle is known as the *adductor tubercle*, and forms an important landmark and guide to the course of the femoral artery. The lower border of the planum popliteum lies horizontally, and corresponds to the upper margins of the condyles and to the line, **linea intercondyloidea**, which forms the upper limit of the notch, or fossa separating these articular surfaces.

The expanded lower extremity of the femur is mainly formed by two massive processes, the **condylus medialis** and **condylus lateralis**, which bear upon their inferior and posterior aspects smooth articular facets for the upper surface of the tibia. If the bone be examined from below, or behind, a deep notch, the **fossa intercondyloidea**, will be seen separating the condyles from one another. Anteriorly they are not sharply separated, and the articular surfaces of the condyles are continuous with a grooved pulley-like facet, the **facies patellaris**, with which the patella, or knee-cap, articulates.

If the student examine the lower end of the bone from behind, he will see that from this aspect the condyles resemble one another, each forming a somewhat knuckle-shaped, backwardly projecting process, convex from above downwards, and convex also from side to side. The condylus lateralis is slightly wider from side to side than the condylus medialis, but otherwise the resemblance between the condyles when viewed from behind is very striking.

If the bone be now inverted so that its under aspect may be examined, it will be seen that the articular surface of the condylus medialis when traced forwards bends outwards, and

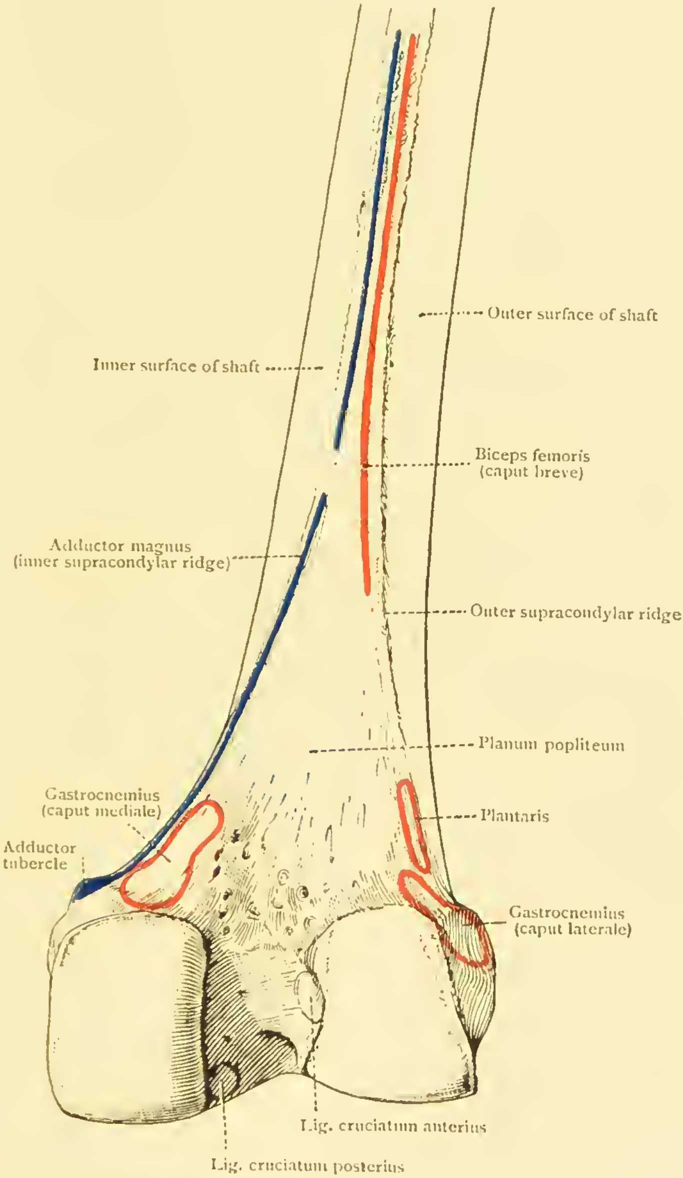

FIG. 67.—Lower end of right femur from behind, showing muscular attachments.

also that the condylus medialis is distinctly narrower from side to side than the condylus lateralis. It will further be noted that the articular facets of both condyles become continuous with the facies patellaris in front of the fossa intercondyloidea, and that the lines of junction are merely indicated by slight notches at the edges of the articular surface, and sometimes also by indistinct sulci. These notches and sulci, which are best seen in fresh specimens before the articular cartilage is

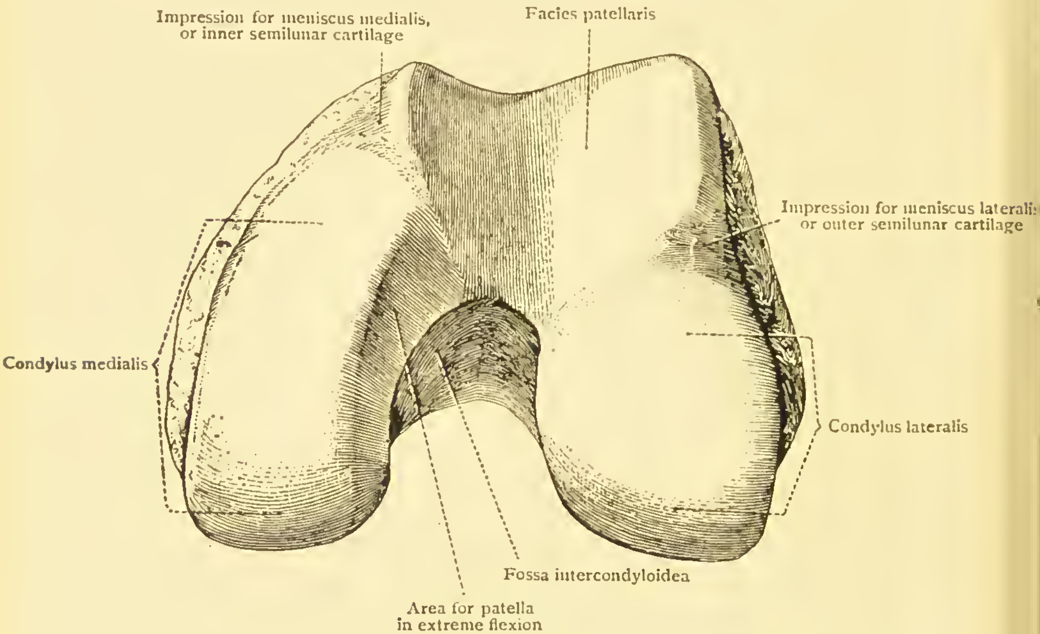

FIG. 68.—Left femur viewed from below, showing the articular surfaces.

removed, or shrunken by drying, lodge the anterior edges of the interarticular semilunar cartilages, or menisci, when the knee-joint is fully extended. A careful examination of the under aspect of the condylus medialis will reveal along its outer edge, where it bounds the fossa intercondyloidea, a narrow, curved, somewhat crescentic bevelled area or facet, which articulates with the inner part of the posterior surface of the patella in full flexion of the knee-joint. No such facet is to be seen on the condylus lateralis.

In examining the lower end of the bone, it should always be borne in mind that the condylus medialis and lateralis reach downwards to the same level, so that the same horizontal plane would touch the articular surfaces of both condyles. The obliquity of the shaft of the femur often leads the student, incorrectly, to place the condylus medialis on a lower plane than the condylus lateralis.

The **facies patellaris** is a grooved articular area on the under and anterior aspect of the inferior extremity of the femur. It lies in front of the articular surfaces of the condyles, with which it is continuous, and in front of the fossa intercondyloidea. The outer edge of the grooved pulley-like surface is more prominent than the inner, and extends to a higher level on the anterior aspect of the bone. The posterior aspect of the patella articulates with the facies patellaris of the femur.

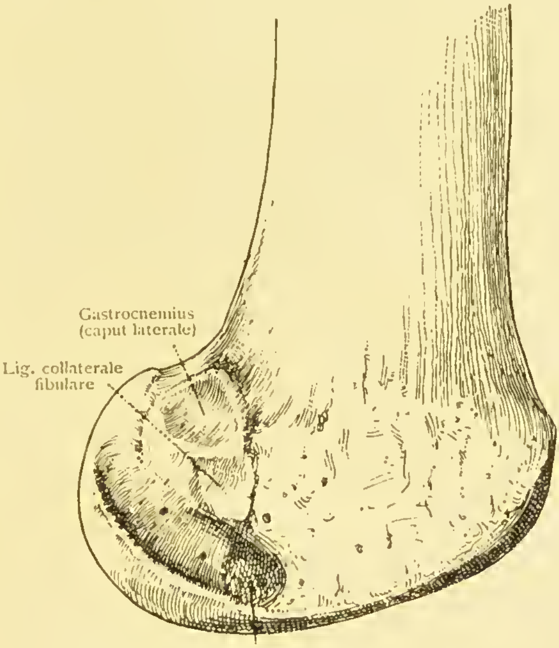

Fig. 69.—Outer aspect of condylus lateralis: right femur.

The outer aspect of the condylus lateralis is surmounted by a convex prominence, called the **epicondylus lateralis**, or tuberosity of the external condyle, to which is attached the ligamentum collaterale fibulare, or external lateral ligament, of the knee. Below the most projecting part of this epicondylus there will be seen a curved groove, lying just above the outer margin of the articular surface of the condyle. The groove ends in front in a pit-like depression, from which the tendon of the popliteus muscle springs. During flexion of the knee-joint the tendon of the muscle occupies the groove, but in extension the tendon passes downwards from its origin and the groove is empty. Above the point of attachment of the ligamentum collaterale, is a slightly depressed area for the origin of the tendinous part of the caput laterale of the gastrocnemius. These markings afford a ready means for the identification of the epicondylus lateralis.

On the opposite side of the bone the inner aspect of the condylus medialis rises in a prominence known as the **epicondylus medialis**, or tuberosity of the internal condyle, to which is attached the ligamentum collaterale tibiale, or internal lateral ligament, of the knee. The adductor tubercle lies above and behind the most projecting part of the epicondylus medialis.

The **fossa intercondyloidea** is the notch-like depression which intervenes between the two condyles. In front it reaches as far as the posterior edge of the facies patellaris; above and behind, it is bounded by the linea intercondyloidea. During life the fossa lodges the eminentia intercondyloidea, or spine, of the tibia, and also the strong ligamenta cruciata genu, or crucial ligaments. These ligaments are fixed to the sides of the fossa, the anterior ligament at a point far back on the outer wall, and the posterior ligament far forwards on the inner wall. Usually impressions may be seen which indicate the points of attachment of these ligaments. The strong posterior ligament of the knee is fixed to the linea intercondyloidea.

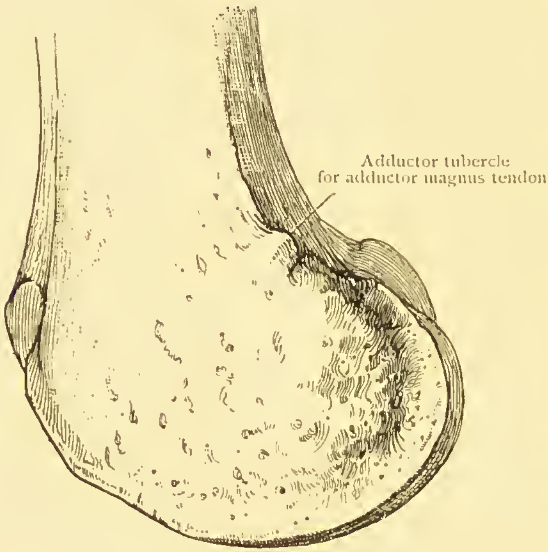

FIG. 70.—Inner aspect of condylus medialis: right femur.

ARTICULATION OF THE FEMUR WITH THE OS COXAE.

Having selected a femur and an os coxae of the same side, the student should study the manner in which they articulate. He will notice that the articulation is of the nature of a ball-and-socket joint, and that the greater part of the head of the femur is received into the socket formed by the acetabulum. During life the joint is rendered very secure, not merely by the strong ligamentum ilio-femorale, which passes from the region of the spina iliaca anterior inferior to the linea intertro-chanterica, and the other ligaments forming the capsule of the joint, but also by a firm fibro-cartilaginous ring which is attached all round the margin of the socket and embraces the head of the thigh-bone. This latter structure is known as the labrum glenoidale, or cotyloid ligament, and is continued across the incisura acetabuli as the ligamentum transversum acetabuli.

The movements which take place at the joint include *flexion*, or forward movement of the thigh-bone ; *extension*, or backward movement ; *abduction*, or outward movement, and *adduction*, or inward movement. In addition the femur may be *rotated* inwards and outwards, and it may also be *circumducted*, as, for instance, when the lower limb is moved so that the foot describes a circle upon the floor. In the extended condition of the hip-joint the thigh occupies a vertical position, as in standing erect ; in extreme flexion the front of the thigh is in contact with the abdomen.

THE BONES OF THE LEG.

The bones of the leg are two in number, namely, the *tibia* and the *fibula*. The tibia is much the more massive and stronger of the two, and it alone articulates with the femur at the knee. Through the tibia the weight of the body is transmitted to the foot at the ankle-joint. The fibula is more slender and lies to the outer side of, and somewhat behind the tibia. It forms the outer prominence of the ankle, but takes no share in the formation of the knee-joint, or in the transmission of the weight of the body.

THE TIBIA.

The **tibia**, unlike the femur, will be noticed to occupy a vertical position, its upper larger extremity supporting the condyles of the femur and its lower end resting on the talus, or astragalus, at the ankle-joint.

The shaft, or **corpus tibiae**, is distinctly triangular in section, and is more slender than either of the extremities.

The anterior part of the tibia can be easily recognized as it is formed by a sharp border, known as the crest of the tibia, or **crista anterior**. The crest is well defined in the upper two-thirds of the shaft of the tibia, and separates the inner from the outer surface of the bone. In the living subject, it can be readily felt beneath the skin. Superiorly, the crest ends in a rough prominence, the **tuberositas tibiae**, which occupies the anterior aspect of the bone a short distance below the knee-joint, and affords insertion to the ligamentum patellae. Inferiorly, the crest becomes rounded, and replaced by a smooth surface, convex from side to side, over which the tendons pass to reach the dorsum of the foot.

The inner surface, or **facies medialis**, of the tibia lies to the inner side of the crista anterior and is subcutaneous throughout the whole length of the bone, from the knee to the ankle-joint. This surface is slightly convex from before backwards and is bounded posteriorly by the **margo medialis**.

To the outer side of the crista anterior lies the outer surface, or **facies lateralis** of the tibia. This surface is slightly concave from before backwards in its upper part where it gives origin to the powerful tibialis anterior muscle. Inferiorly, where the crista anterior fades away, the facies lateralis becomes continuous with the convex anterior aspect of the lower end of the tibia.

The facies lateralis is limited behind by a ridge for the attachment of the strong membrana interossea cruris, which binds the tibia to the fibula. This ridge, spoken of as the **crista interossea**, or interosseous border, divides near its lower end to enclose a rough area for the attachment of the interosseous ligament.

When the tibia is viewed from behind it will be noticed that there is a well-defined posterior surface, the **facies posterior**, bounded by the crista interossea on the outer, and the margo medialis on the inner side. The student will not fail to notice an oblique rough line which runs from above downwards and inwards, and marks off a somewhat triangular district upon the upper part of the facies posterior of the tibia. This rough line, the **linea poplitea**, or *oblique line*, indicates the origin of the tibial head of the soleus muscle; the area of bone above it gives insertion to the popliteus. The portion of the facies posterior below the linea poplitea is smooth and is divided into two elongated areas by a slight, sometimes a well-defined, vertical ridge. The inner of these areas affords origin to the flexor digitorum longus; and the outer, which lies immediately behind the margo interossea, gives attachment to the tibialis posterior muscle. The **foramen nutricium**, which is of large size, lies on the facies posterior in the region of, or just below, the linea poplitea. It enters the bone very obliquely and is directed downwards.

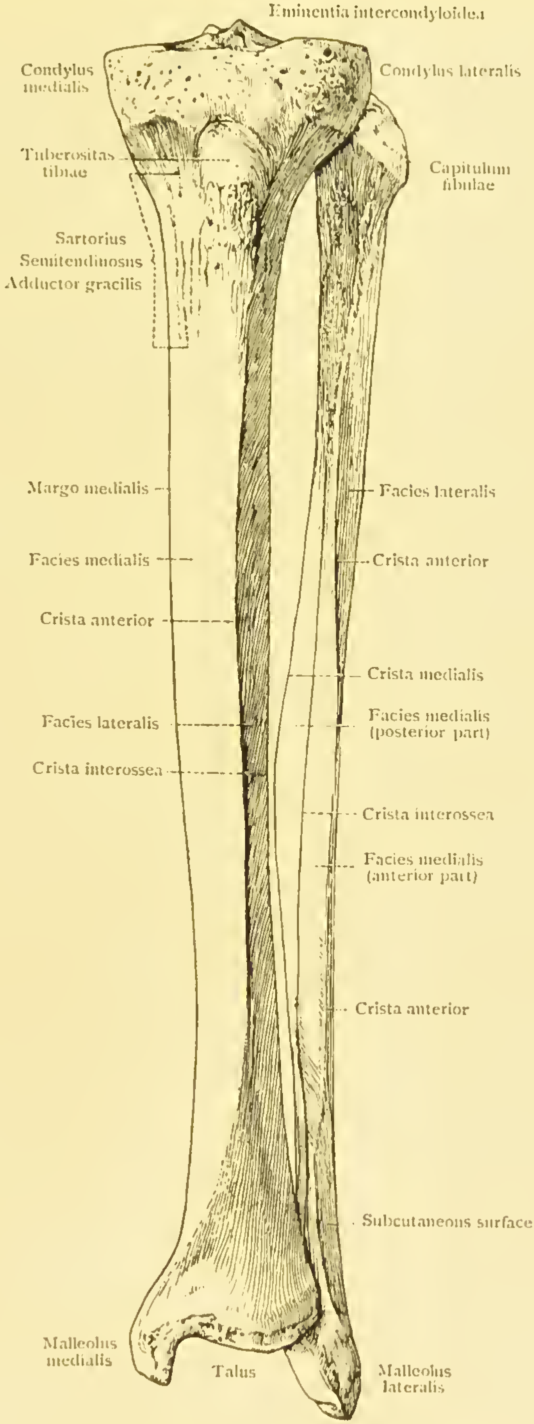

FIG. 71.—Bones of the left leg from in front.

The upper end of the tibia is expanded, and considerably wider from side to side than from before backwards. It projects both inwards and outwards beyond the margins of the shaft, and forms on each side a convex mass known as a condylus, or tuberosity. When the leg-bones are viewed from behind it will be seen that the **condylus lateralis**, or *outer tuberosity*, lies above and internal to the capitulum, or head of the fibula, and carries on the under part of its posterior aspect an articular facet for this bone. The **condylus medialis**, or *internal tuberosity*, shows on its posterior aspect a shallow, horizontally placed sulcus, into which a part of the tendon of the musculus semimembranosus is inserted. The presence of these markings makes the identification of the condyles an easy matter. The anterior aspect of the upper end of the tibia is convex from side to side, and extends downwards as low as the rough tuberositas tibiae, which, as we have seen, marks the insertion of the ligamentum patellae. Viewed from in front, the convex surface of the upper extremity exhibits a somewhat triangular outline, the apex of which is directed downwards and lies at the tuberosity of the tibia, and the base forming the anterior margin of the upper end of the bone. The ligamentum collaterale tibiale, or internal lateral ligament of the knee, is attached to the shaft immediately below the inner part of the condylus medialis, and the ilio-tibial band of the fascia lata is inserted into the prominent outer part of the condylus lateralis.

On the upper surface of the tibia, there are two large slightly concave, oval, articular facets, one for each of the condyles of the femur. Anteriorly, and posteriorly, these facets are separated by somewhat triangular rough areas, which meet together in the region between the articular surfaces at the highest part of the tibia. The raised central part of the upper surface of the tibia lies, when the femur is in position, in the fossa intercondyloidea of the latter bone. It forms the **eminentia intercondyloidea**, and is often spoken of as the *spine of the tibia*. It is divided into inner and outer tubercles, which are separated by a slight notch, or depression. The inner tubercle is usually the higher.

A careful examination shows that the articular areas for the condyles of the femur differ from one another, and may readily be distinguished. The surface for the condylus medialis is larger, longer from before backwards, and more oval in outline than the corresponding area for the condylus lateralis. The latter possesses a more nearly circular outline. In each case

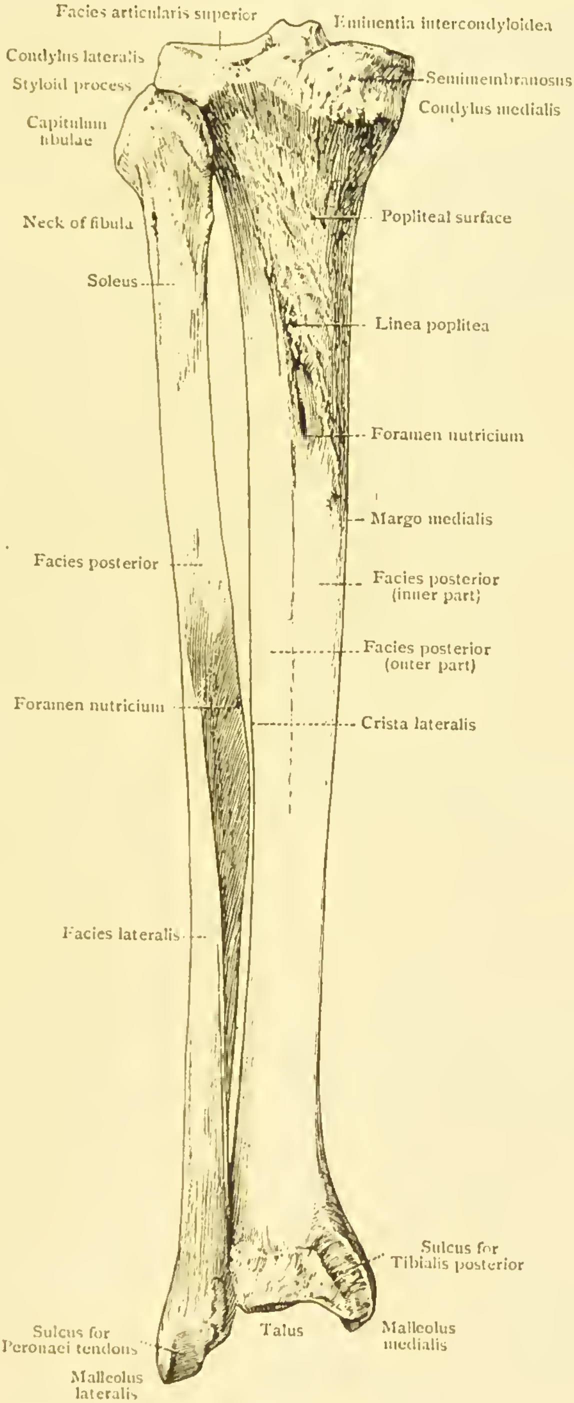

FIG. 72.—Bones of the left leg from behind.

the smooth cartilage-covered surface is continued on to the slope of the adjacent tubercle as high as its summit. Round the circumference of each of the articular facets is a flat district on which rests, during life, a crescentic fibro-cartilaginous meniscus which serves to deepen the cavity for the condyle of the femur, and adapts itself to the movements of the bones at the knee-joint. The anterior and posterior horns of the menisci are fixed to the tibia in front of and behind the intercondylar tubercles; those for the external fibro-cartilage coming closer together than those for the internal. The rough

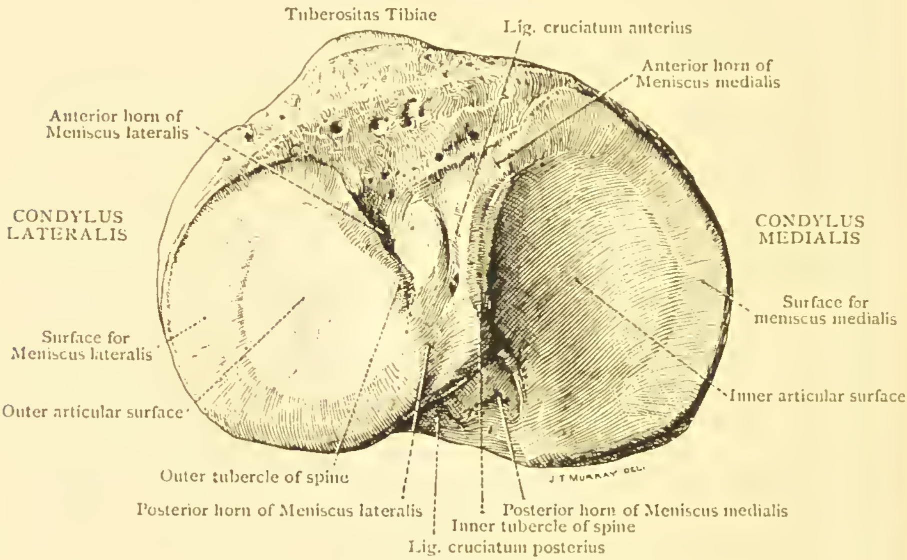

FIG. 73.—Upper surface of left tibia.

area which intervenes in front, between the articular surfaces, is related to a pad of fat within the cavity of the knee-joint, and immediately anterior to the external intercondylar tubercle it gives attachment to the ligamentum cruciatum anterius. The corresponding posterior ligament springs from a sloping area which intervenes between the articular surfaces posteriorly. In a well-marked bone, and especially when the articular cartilage is still in place, it will be found that the outer facet is flat, or slightly convex, from before backwards; and that posteriorly its edge is somewhat rounded, and carried a little downwards and backwards, on to the posterior surface of the upper end of the bone. The margin of the internal facet is more sharply defined, and the whole surface is concave from before backwards, as well as from side to side.

The lower end of the tibia, less massive than the upper, is wider from side to side than from before backwards. Its inner part projects downwards, forming the subcutaneous prominence of the inner ankle. To it the name **malleolus medialis** is applied. The student should not fail to make himself familiar with the appearance and shape of this part of the bone, as, in the living subject, it forms a most important landmark at the ankle. The lower edge of the malleolus is marked by a depression for the attachment of the strong ligamentum deltoideum, or internal lateral ligament of the ankle; the lowest point on the tibia lies just in front of this depression. Behind the malleolus there is a shallow, obliquely disposed groove, the **sulcus malleolaris**, which transmits the tendon of the tibialis posterior. On the outer aspect of the malleolus medialis lies an articular facet, deeper in front than behind, for the inner side of the talus bone. This facet is

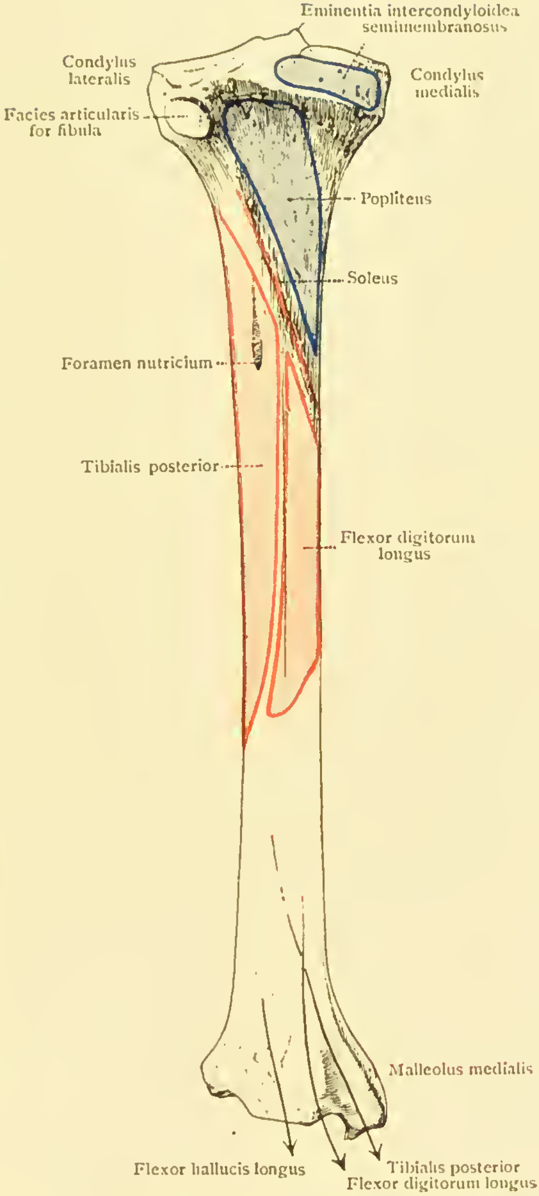

FIG. 74.—Left tibia seen from behind, showing muscular attachments.

continuous with the large articular area on the under surface of the tibia, which also articulates with the talus

The anterior surface of the lower end of the tibia is rounded and convex, and in the living subject is crossed by the tibialis anterior tendon, the tendons of the extensors of the toes, and the blood-vessels and nerves for the dorsum of the foot. Its lower edge gives attachment to the anterior ligament of the ankle.

The posterior aspect of the lower end of the bone bears the upper end of the sulcus malleolaris already mentioned, and sometimes a less defined sulcus for the tendon of the long flexor of the great toe.

The outer aspect of the lower end of the tibia is in contact with the fibula, and is concave from before backwards. It forms a hollow, the **incisura fibularis**, in which the fibula rests; the two bones being firmly united by a strong interosseous ligament which is attached to the adjacent rough bony surfaces. The area on the tibia for the attachment of this ligament is approximately triangular in outline; its anterior border is better defined than its posterior, and its apex lies superiorly, at the point where the crista interossea divides. Just below the rough area is a small smooth district, which lodges an upward prolongation of the synovial membrane of the ankle-joint.

When the tibia is viewed from below, a large articular surface for the upper surface of the talus is seen. This is quadrilateral in outline, concave from before backwards, and very slightly convex from side to side. At its inner end it is continuous with the articular surface on the malleolus already mentioned.

THE FIBULA.

The **fibula** is a long, slender bone which lies to the outside of, and to some extent behind, the tibia. In the articulated skeleton, the student will notice that the position of the fibula is such that it takes no share in the formation of the knee-joint, or in supporting the weight of the body, but it plays an important part in the articulation of the ankle. The upper end of the fibula joins the under and posterior aspect of the outer condyle of the tibia at the smooth facet already noticed on that bone. At its lower end, the fibula is firmly united to the tibia by a strong interosseous ligament, and projects downwards, forming the outer ankle, or **malleolus lateralis**, for articulation with the talus.

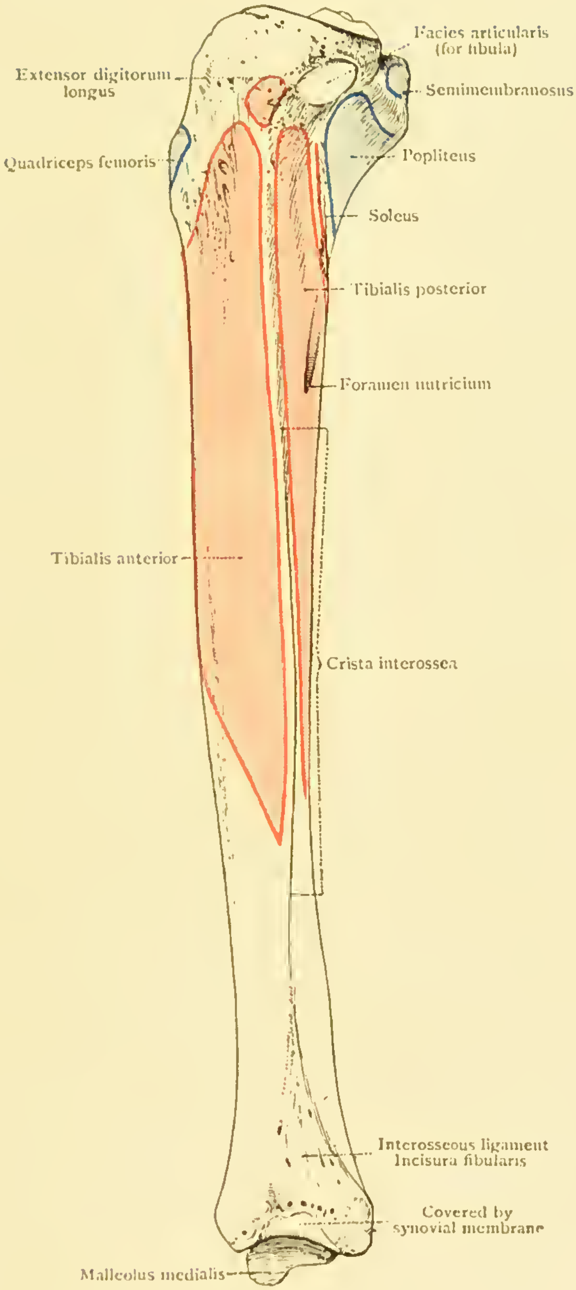

FIG. 75.—Left tibia from outer aspect, showing muscular attachments.

Fig. 76.—Left fibula from inner aspect.

The upper end of the fibula is slightly expanded, and is spoken of as the **capitulum**, or head. It may be distinguished by its somewhat globular outline from the lower end, which is flattened from side to side. Upon the upper surface of the capitulum the student will notice a smooth, flat, nearly circular facet which is directed upwards, inwards, and slightly forwards, for articulation with the corresponding facet on the under and posterior aspect of the condylus lateralis of the tibia. The highest point on the fibula lies just above and behind this facet, and is called the *styloid process*, or **apex capituli fibulae**. The upper and outer part of the capitulum shows a mark, which indicates the insertion of the biceps tendon and also the attachment of the ligamentum collaterale fibulare, or external lateral ligament of the knee. The term *neck* is often applied to the upper, more slender part of the shaft of the fibula which lies immediately below the capitulum.

The lower end of the fibula, or **malleolus lateralis**, is flattened from side to side, and deep from before backwards. On its inner, or tibial, side is a triangular facet for the outer aspect of the talus, above which is a rough area for the tibio-fibular interosseous ligament. Behind and below the facet for the talus there is a well-marked pit, or depression, for the attachment of a strong ligamentous band which passes to the posterior end of the talus and forms the ligamentum talofibulare posterius, or posterior bundle of the external lateral ligament of the ankle. The position of this pit affords the student a ready means of recognizing the side to which any fibula belongs.

The outer side of the malleolus is smooth and lies subcutaneously in the living subject; its lower and anterior border is marked for the attachment of ligamentous bands which pass to the neck of the talus and to the calcaneus.

When the malleolus is viewed from behind, a smooth, shallow sulcus may often be seen descending on its posterior aspect. This lodges the tendons of the peronaeus longus and brevis muscles.

The shaft, or **corpus fibulae**, is very variable in its curvature and markings. Usually it is bent so as to be slightly convex backwards in its long axis, but in many cases this curvature is only to be recognized towards the upper and lower extremities of

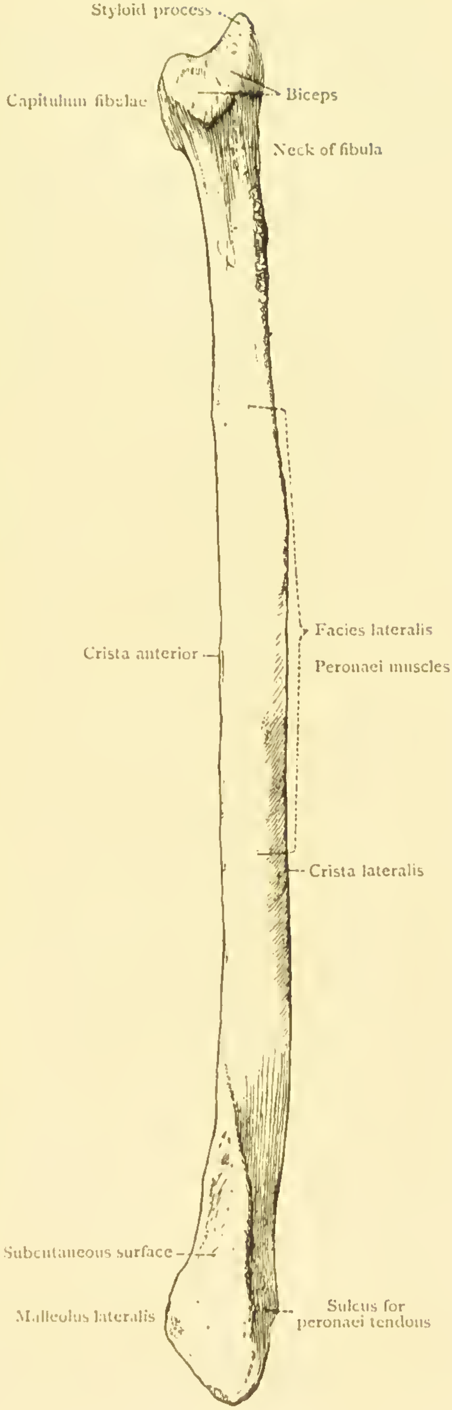

FIG. 77.—Left fibula from outer side.

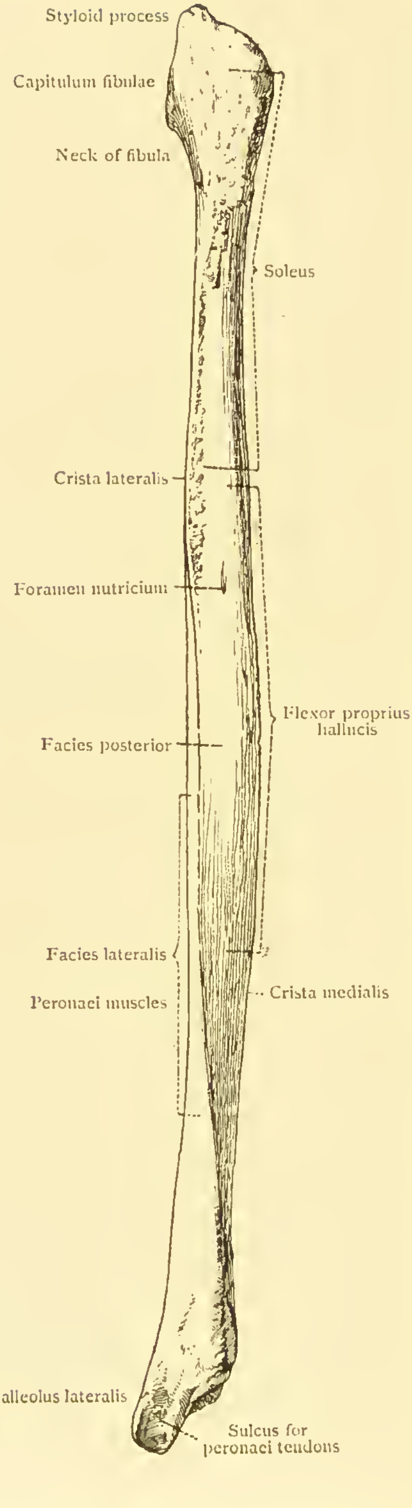

FIG. 78.—Left fibula from behind.

the bone, which are always bent slightly forwards.

Three surfaces are described upon the fibula, and these are most readily recognized in the middle and upper thirds of the bone. If the student hold the fibula in its normal position, he can in its middle third easily identify a posterior, an inner and an outer surface, which are named *facies posterior*, *medialis* and *lateralis*. These are separated by inner, anterior, and outer borders, named *crista medialis*, *anterior* and *lateralis*.

The **crista anterior** gives attachment to the inter-muscular septum, which separates the muscles on the front from those on the outer aspect of the leg. When it is traced downwards it will be seen to divide into two limbs which enclose between them the subcutaneous outer part of the lower end of the bone. This arrangement makes the recognition of the crista anterior an easy matter.

The **crista lateralis** and the **crista medialis** which bound the facies posterior are usually rounded and less sharply defined. In the middle third of the fibula they form the outer and inner edges of the bone. The crista medialis gives attachment to a strong layer of fascia which covers the tibialis posterior; the crista lateralis to the intermuscular septum which intervenes between the muscles on the outer and posterior aspects of the leg.

The **facies lateralis** gives origin to the peronaei muscles, longus and brevis, and is usually concave from before backwards. When it is traced downwards the facies lateralis will be seen to pass gradually around to the posterior aspect of the bone, and to end below at the back of the malleolus in the groove for the peronaei tendons, already mentioned.

The **facies posterior** is rough in the upper third, or fourth of the bone, where it affords origin to the fibular head of the soleus muscle; lower down it is smooth, and gives origin to the flexor hallucis longus. Towards the lower end of the fibula the facies posterior winds round on to the inner aspect of the bone towards the extensive rough area which gives attachment to the interosseous tibio-fibular ligament.

The **facies medialis** is subdivided into anterior and posterior portions by a ridge which gives attachment to the interosseous membrane, and is hence called the **crista interossea.** This ridge is variable in its position; in some bones it almost coincides with the crista anterior, and then the anterior portion of the facies medialis is very narrow; in other cases the ridge divides the facies medialis into two approximately equal areas. The *anterior area* of the facies medialis gives origin to the extensor digitorum longus, extensor hallucis longus, and

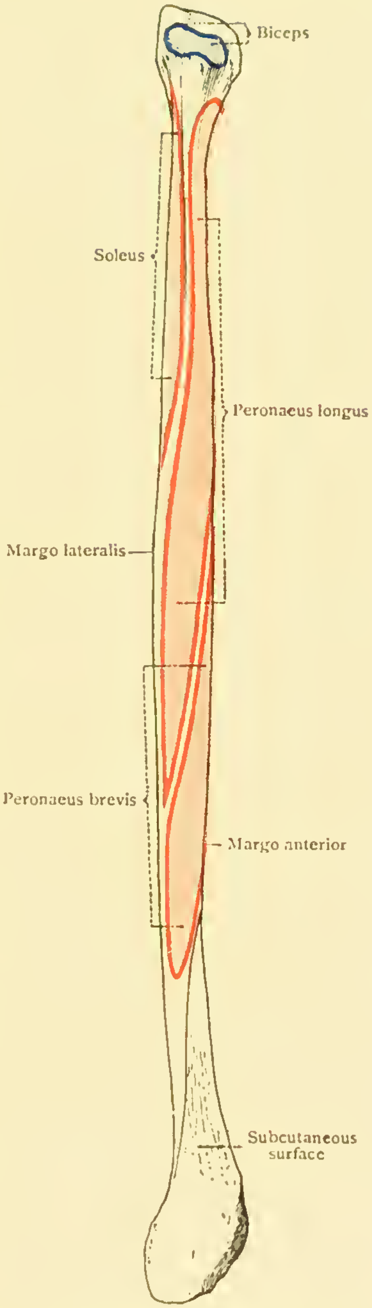

FIG. 79.—Right fibula from the outside, showing muscular attachments.

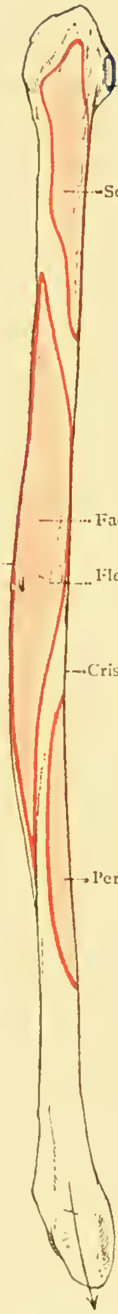

Fig. 80.—Right fibula from behind, showing muscular attachment.

peronaeus tertius muscles; the *posterior area* gives origin to the tibialis posterior. The crista interossea which separates these areas is usually best marked on the middle third of the facies medialis.

In his examination of the fibula, the student will not have failed to notice that the shaft appears as if it were twisted in its long axis, and that, as a result, the outer surface comes to lie posteriorly, and the posterior surface internally, at the lower end of the bone.

Before completing the study of the fibula, it is well to carefully observe the size and form of the subcutaneous surface at the lower end of the bone, at and above the malleolus. This part of the fibula can be readily examined in the living subject, and is a region in which fracture not infrequently occurs.

The circumference of the capitulum, on its anterior, outer, and posterior parts, should also be examined, and its position should be determined in the limb of the living subject. Finally the position of the bones of the leg should be carefully studied in the articulated skeleton. The student should note the position of the capitulum fibulae below and behind the condylus lateralis of the tibia; also the lower level, and the more posterior position of the malleolus lateralis compared with the malleolus medialis. Further it is important to observe that the shaft of the fibula lies, not only to the outside of, but also behind that of the tibia.

During life the tibia and fibula are bound so firmly together that only an extremely slight degree of movement can take place between the bones.

THE PATELLA.

The **patella**, or knee-cap, is to be regarded as a large sesamoid bone developed in the tendon of the quadriceps femoris muscle. It has a somewhat rounded, or widely oval outline, and is flattened from before backwards. Its lower end is pointed, and is known as the **apex patellae**. From this part of the bone, the strong ligamentum patellae passes downwards to be attached to the tuberositas tibiae. The upper border, or **basis patellae**, is wide from side to side, and thick from before backwards. To it is attached the common tendon of the quadriceps muscle. The convex inner and outer margins of the bone give insertion to the vastus medialis and vastus lateralis muscles.

The anterior surface of the patella is rough, and marked by numerous longitudinal striae, into which some of the superficial fibres of the quadriceps

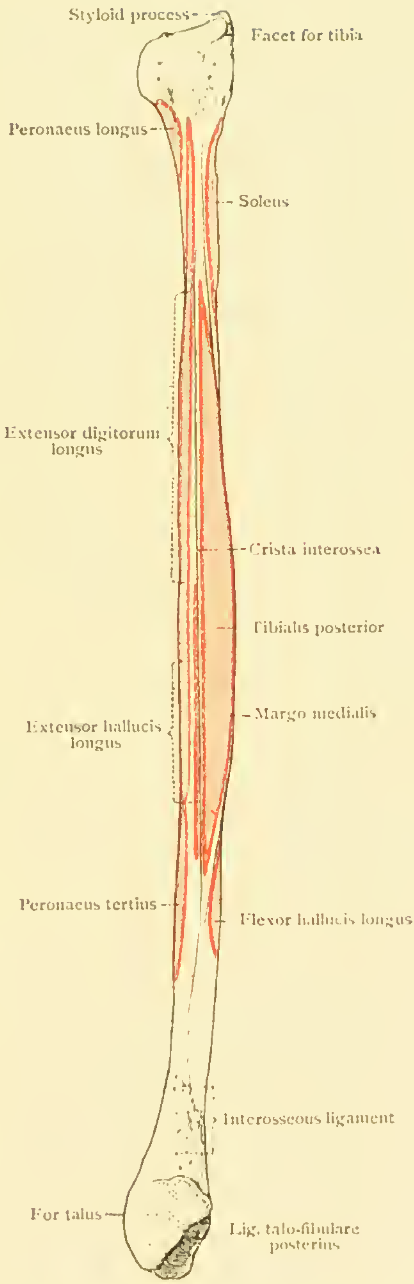

Fig. 81.—Right fibula from inner aspect, showing muscular attachments.

femoris tendon are continued. Between it and the skin lie the important bursae praepatellares.

The posterior surface is smooth, and covered with articular cartilage, except near the apex patellae. The articular surface is divided into inner and outer facets by a smooth vertical articular ridge, which lies in the groove formed by the facies patellaris of the femur. The outer facet on the patella, in agreement with the greater extent of the outer lip of the facies patellaris of the femur, is larger than the inner. Close to the inner margin of the patella, a narrow vertical area may

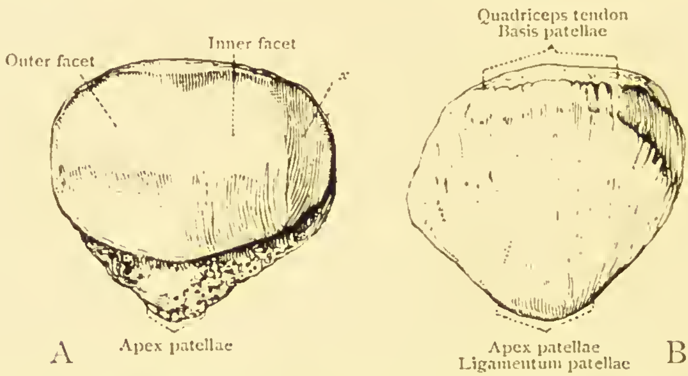

FIG. 82.—Left patella, A, from behind, and B, from in front. *x*, facet for condylus medialis in extreme flexion.

be seen for articulation with the outer edge of the condylus medialis in extreme flexion of the knee-joint (figure 68). These facets on the posterior surface of the patella are best seen in bones in which the articular cartilage is still in place.

THE KNEE-JOINT.

Having selected a femur, tibia, and patella of the same side, the student should examine the manner in which they articulate at the knee-joint. The articulating surfaces are very extensive, and the joint cavity is the largest in the body. It will be apparent that there is extremely little interlocking of the bones, and that the knee depends mainly for its strength on the powerful ligaments which unite the femur and tibia.

The movements which take place at the knee-joint are extension and flexion. During these movements, the facies articularis superior of the tibia glides over the articular surfaces of the condyles of the femur. When the joint is extended, the tibia is brought into line with the femur, and most of the strong ligaments which connect the bones are put on the stretch. When the joint is flexed, these ligaments are slackened and a slight degree of rotation of the tibia on the femur can take place.

It must be remembered, however, that a very imperfect idea of the knee-joint is obtained by examining the dry bones, and that an accurate knowledge can be acquired only by a careful study of the fresh joint before removal of the important ligaments, and of the interarticular menisci which assist in adapting the femoral and tibial articular surfaces to one another. The manner in which these latter structures are related to the tibia, and to the femur in extension of the knee-joint, has already been indicated.

In flexion and extension of the knee, the patella glides in the groove formed by the facies patellaris of the femur. In extreme flexion it sinks partly into the fossa intercondyloidea, and then its inner vertical facet rests upon the narrow crescentic area upon the condylus medialis, which lies, as we have seen, close to the inner wall of the fossa intercondyloidea (figure 68). In full extension of the knee, the patella lies to a large extent above the facies patellaris of the femur. It should be noticed that only a relatively small part of the posterior surface of the patella rests against the articular surface of the femur in any one position of the knee-joint.

The student should practise in his own knee the identification of the patella in different positions of the joint, and he should also familiarize himself by touch with the outlines of the epicondyles and condyles of the femur. In such examination the condyles can be most easily felt when the knee is flexed. The upper edges of the condyles of the tibia should also be identified; and the position of the capitulum of the fibula, below and behind the condylus lateralis tibiae, should be established.

THE FOOT.

In the articulated skeleton of the foot we recognize the **tarsus**, composed of seven **ossa tarsi**; the **metatarsus** with its five **ossa metatarsalia** arranged approximately parallel to one another; and the **phalanges** which form the skeleton of the toes. The bones of the tarsus are large and massive in comparison with the corresponding bones in the hand which form the carpus. The metatarsal bones and the phalanges of the toes resemble the metacarpals and the phalanges of the fingers, except that in the foot the phalanges are much shorter than in the hand, in agreement with the shorter length of the toes in comparison with the fingers.

The student should first identify and make himself familiar with the position of the tarsal bones in the articulated foot, and then study isolated examples of each bone.

THE TARSUS.

The **ossa tarsi**, or tarsal bones, are named as follows:— **talus, calcaneus, os naviculare, os cuneiforme primum, os cuneiforme secundum, os cuneiforme tertium,** and **os cuboideum.**

The talus alone articulates with the tibia and fibula, and takes part in the formation of the ankle-joint; the calcaneus forms the prominence of the heel, and projects backwards beyond the axis of the ankle-joint. The os cuboideum lies between the outer two metatarsal bones and the anterior end of the calcaneus; on its inner side lie the three ossa cuneiformia; and the interval behind them, and in front of the talus, is occupied by the os naviculare. The diagram (figure 83) will assist the student in recognizing the individual bones.

THE TALUS.

The **talus**, often called *astragalus*, occupies the highest part of the foot, and rests upon the calcaneus. In it we recognize a *head*, **caput tali**; a *neck*, **collum tali**; and a *body*, or **corpus tali**. The caput tali points forwards, slightly inwards, and downwards.

The **corpus tali** is the wide and massive posterior part of the bone, and on its upper aspect is a conspicuous pulley-like structure, the **trochlea tali**, which articulates with the tibia and fibula at the ankle-joint.

The upper articular surface, or **facies superior**, of the trochlea is smooth and convex from before backwards, and very slightly concave from side to side; it glides on the under surface of the tibia in flexion and extension of the ankle-joint. It will be noticed that the trochlea is somewhat wider in front than behind; hence the talus is more firmly supported by the tibia and fibula in the dorsi-flexed position of the ankle.

The inner surface of the trochlea bears a small, somewhat pear-shaped articular facet for the outer aspect of the malleolus medialis. This facet is deeper in front than behind, and is separated from the facies superior of the trochlea by a rounded articular edge, which runs straight from before backwards.

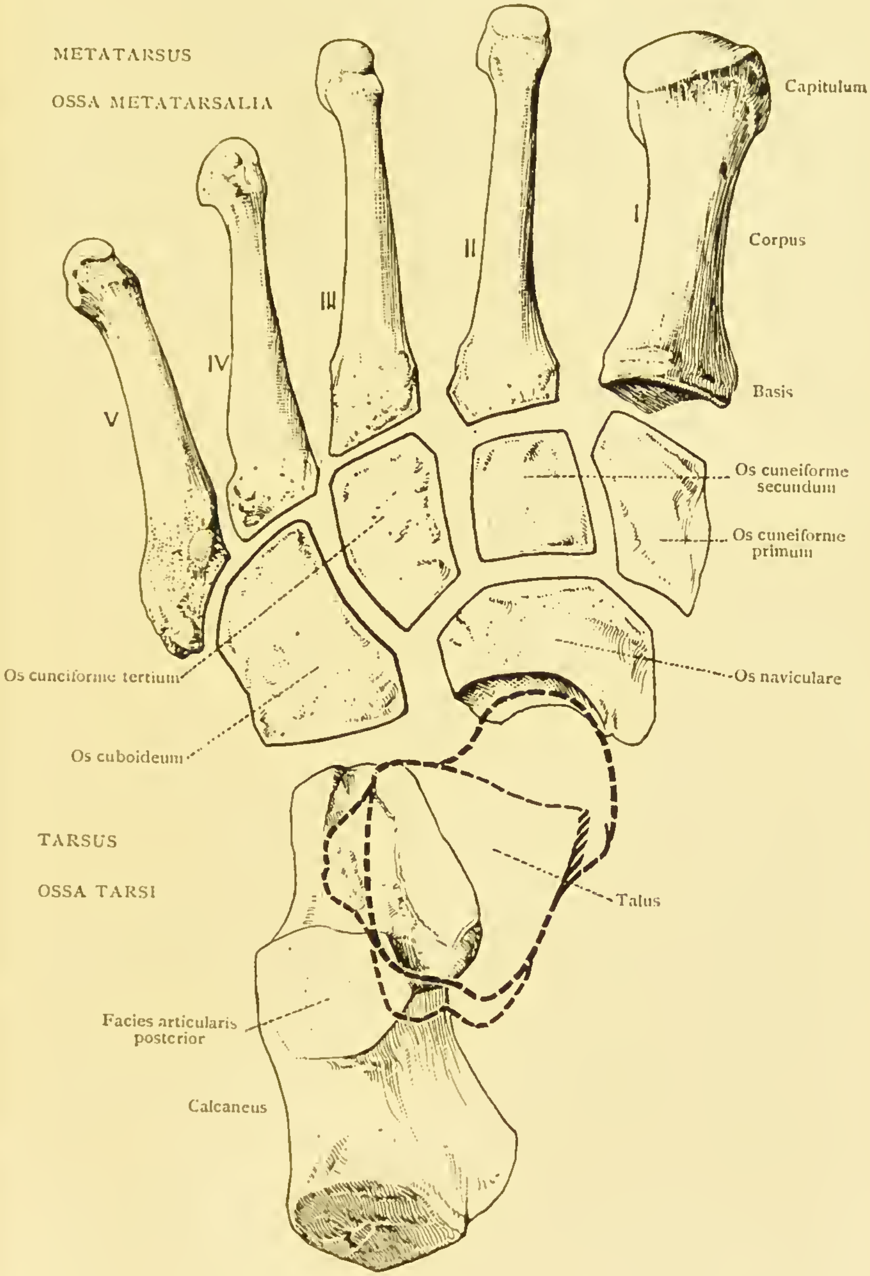

FIG. 83.—Tarsus and metatarsus of left foot, from the dorsal aspect.

The outer surface of the trochlea is covered by a much larger articular facet for the fibula, which is concave from above downwards and has the outline of a quadrant of a circle. At the lower angle of this area the bone projects outwards and forms the **processus lateralis tali**. When the student has learnt to identify the facet for articulation with the fibula, he will have no difficulty in recognizing to which side any talus belongs.

The edge which intervenes between the facies superior and the facies malleolaris lateralis of the trochlea, curves somewhat

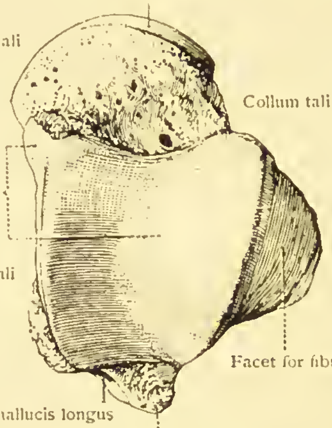

Fig. 84.—Right talus from above.

inwards as it is traced backwards, and in its posterior part articulates with the inferior transverse tibio-fibular ligament when the ankle-joint is dorsi-flexed.

A small portion of the talus projects backwards behind the trochlea and forms a little tubercle, known as the **processus posterior tali**, for the attachment of the ligamentum talo-fibulare posterior, the other end of which springs from the pit-like depression behind the articular area on the lower end of the fibula. To the inner side of this projection a sulcus will be noticed, running downwards and inwards, for the transmission of the tendon of the flexor hallucis longus. Occasionally the processus posterior tali is an isolated ossicle, and is connected to the main portion of the talus by fibrous tissue only. This ossicle, known as the **os trigonum**, is of interest because it represents an element which in some animals is normally distinct.

In front of the trochlea lies the caput tali, connected to the main portion of the bone by a short, thick **collum tali**, or neck. The upper surface of the neck gives attachment to the anterior part of the capsular ligament of the ankle-joint, and sometimes exhibits a pressure facet for the anterior edge of the lower end of the tibia, with which it may be in contact in extreme dorsi-flexion of the ankle-joint.

The under aspect of the talus is divided into anterior and posterior articular areas by a deep sulcus, **sulcus tali**, with a rough floor for the attachment of a strong ligament, which

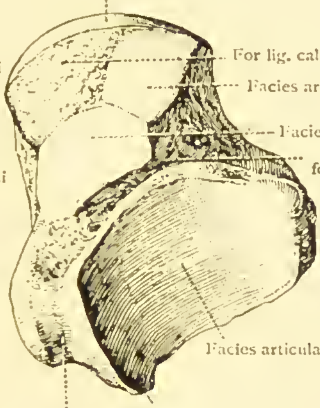

FIG. 85.—Left talus from below.

unites the talus and calcaneus. The sulcus tali is wide externally, and becomes narrow as it is traced inwards and backwards.

The articular area behind the sulcus tali forms a single large, somewhat oval facet, the **facies articularis calcanea posterior**, which is concave in its long axis, and rests upon a facet on the upper surface of the corpus calcanei.

The area in front of the sulcus consists of two much smaller oval facets, usually continuous with one another, the **facies articularis calcanea media** and **anterior**. The latter of these lies on the under surface of the caput tali, the former on the anterior and inner part of the corpus tali.

The greater portion of the **caput tali** is covered by a uniformly convex, oval, articular facet, the **facies articularis navicularis**, which is directed forwards, inwards, and downwards, to rest against the concave posterior aspect of the os naviculare. Behind the inner part of this facet, and immediately in front of the facies articularis calcanea media, a somewhat triangular smooth area may be recognized, which, in the living foot, rests against a fibro-cartilaginous ligament, the ligamentum calcaneo-naviculare plantare, connecting the calcaneus and the os naviculare. The cartilage covering this smooth area is usually not so thick as on the other articular surfaces of the bone; in the macerated bone it is usually possible to recognize a difference in the texture of the surface that articulates with the fibro-cartilage.

THE CALCANEUS.

The **calcaneus** is the largest of the tarsal bones. It lies below the talus, and behind the os cuboideum. Its long axis runs from behind forwards, and slightly upwards and outwards. Its posterior and larger end forms the **tuber calcanii**, and projects backwards behind the plane of the ankle-joint, giving rise to the prominence of the heel. Into it is inserted the powerful tendo Achillis or calcaneus. The anterior end of the bone, sometimes spoken of as the *great process*, bears an articular facet for the cuboid.

The upper surface of the bone is easily recognized by the articular facets which it bears for the talus. The most posterior of these, the **facies articularis posterior**, is of large size and somewhat oval in outline; it is convex in its long axis, which is directed downwards, forwards, and slightly outwards. This facet is limited anteriorly by a rough depressed area, the inner part of which forms the **sulcus calcanei**, and lies immediately below the sulcus tali in the articulated foot. When the calcaneus and talus are fitted together, these grooves form a tunnel, the **sinus tarsi**, which is directed inwards, backwards, and upwards, and in the living foot is occupied by strong interosseous ligaments. In front of the sulcus calcanei lie two articular facets for the caput tali. These are usually continuous, and the more posterior of the two, the **facies articularis media**, rests upon a curious inwardly projecting process known as the **sustentaculum tali**. The more anterior facet, or **facies articularis anterior**, is situated upon the extreme anterior and inner part of the calcaneus. The wide, rough area to the outer side of these articular facets is continuous with the sulcus calcanei, and in its outer part gives origin to the extensor digitorum brevis. The part of the upper surface of the bone which lies behind the facies articularis posterior is convex from side to side, and concave from before backwards.

The inner aspect of the calcaneus is readily identified by the projecting shelf-like **sustentaculum tali**. This process articulates superiorly with the talus, and inferiorly it is grooved

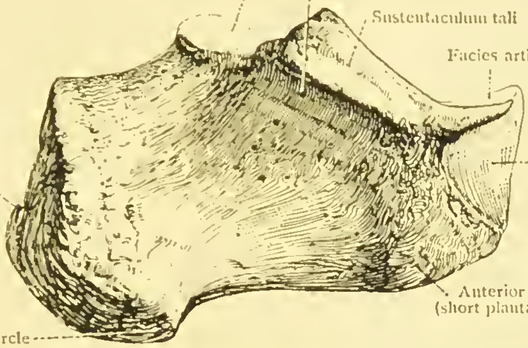

FIG. 86.—Left calcaneus from the inner side.

by the tendon of the flexor hallucis longus. Its inner thickened edge gives attachment to a part of the ligamentum deltoideum of the ankle-joint, and from its anterior border a fibro-cartilaginous ligament, the ligamentum calcaneo-naviculare plantare, passes forwards to reach the os naviculare.

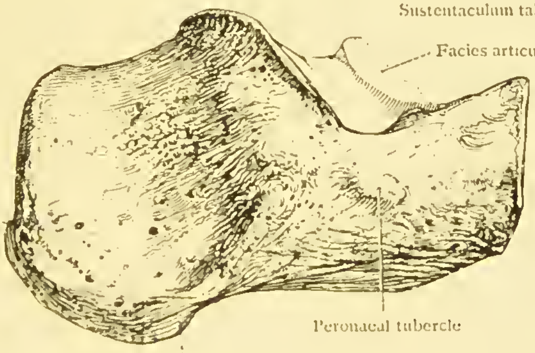

FIG. 87.—Right calcaneus from the outer side.

Below and behind the sustentaculum tali, the inner aspect of the calcaneus is hollowed out to form a wide, smooth groove, through which the tendons, vessels, and nerves pass from the back of the leg into the sole of the foot.

The outer aspect of the calcaneus is distinctly flatter than the inner. On it there may sometimes be seen a small projecting tubercle, known as the **processus trochlearis**, or *peronaeal tubercle*, behind and below which is a groove called the **sulcus peronaei**, for the tendon of the peronaeus longus muscle ; the peronaeus brevis tendon passes above the tubercle. The tubercle and groove are often not recognizable.

The under aspect of the calcaneus is rough and prominent posteriorly where it is continuous with the thickened posterior end of the bone, or **tuber calcanei**. Here two confluent tubercles, the **processus lateralis** and **processus medialis tuberis calcanei** may be recognized. The inner tubercle is the larger, and is ill defined; the outer is smaller, and usually more distinct. These tubercles give attachment to the strong plantar fascia, and also afford origin to the flexor digitorum brevis and the abductors of the great and little toes. The area of bone in front of the tubercles shows a series of longitudinal striae, and affords attachment to the ligamentum plantare longum. Near the anterior end of the under surface there is a slightly raised area forming the *anterior tubercle* for the attachment of the short plantar ligament, or ligamentum calcaneo-cuboideum plantare. This area is usually well defined at its anterior end, but at its posterior end it is continuous with the general under surface of the calcaneus.

The anterior end of the calcaneus articulates with the os cuboideum by a facet which is slightly convex from side to side, and concave from above downwards. It should be noticed that the upper edge of this facet forms a projecting lip, which slightly overlaps the upper part of the os cuboideum.

THE OS NAVICULARE PEDIS.

The **os naviculare** is a flattened bone of oval outline, which lies on the inner margin of the foot. Posteriorly it shows a large, smooth, uniformly concave facet for the caput tali ; and its anterior surface is occupied by three continuous facets for the ossa cuneiformia. From its inner and under aspect, a well-marked, rough tubercle, the **tuberositas ossis navicularis**, points downwards and inwards. The position of this tubercle, which gives attachment to the tendon of the tibialis posterior, will enable the student to recognize the side to which the bone belongs. Very often a small articular facet for the os cuboideum may be seen on the outer part of the bone, close to the anterior margin.

THE OSSA CUNEIFORMIA.

The three **ossa cuneiformia** lie in front of the os naviculare, and are named inner, or primum ; middle, or secundum ; and

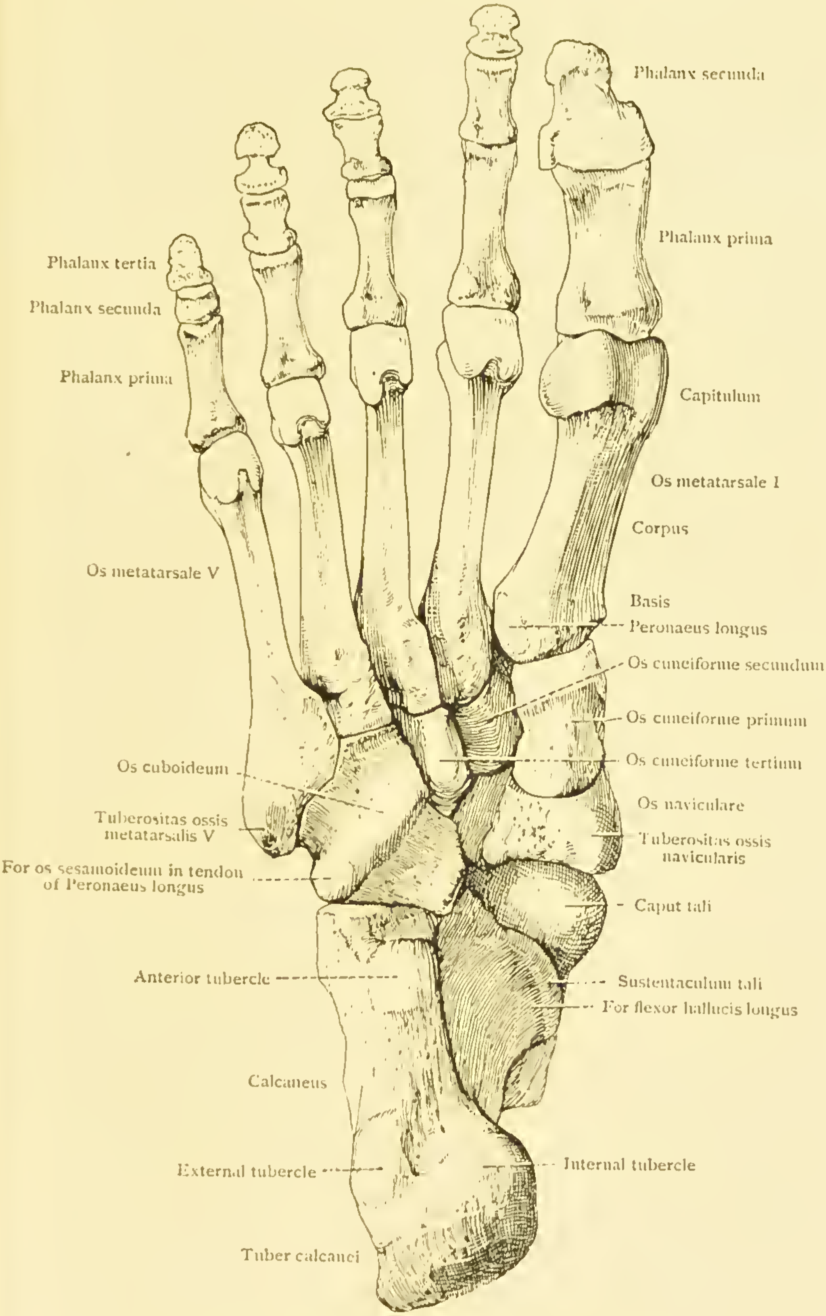

FIG. 88.—Right foot from its plantar aspect.

outer, or tertium. Each is wedge-shaped, and articulates at its distal, or anterior extremity with the corresponding os metatarsale, and at its posterior extremity with the os naviculare.

The **os cuneiforme primum**, or *internal cuneiform*, is the largest of the three ossa cuneiformia, and its anterior surface bears a kidney-shaped facet for articulation with the os metatarsale of the great toe. Posteriorly there is a triangular

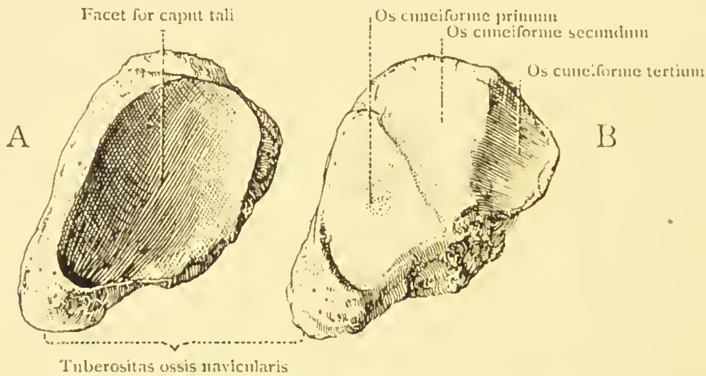

FIG. 89.—A, right os naviculare from behind, B, left os naviculare from in front.

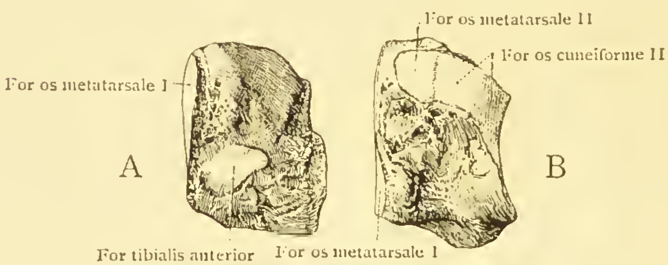

FIG. 90.—A, right os cuneiforme primum from the inner side ; B, left os cuneiforme primum from the outer side.

facet for the os naviculare ; and on the outer aspect of the bone, in its upper and posterior part, there is a facet for the os cuneiforme secundum. In front of this latter facet, and continuous with it, there is a small area for articulation with the os metatarsale of the second toe. The remainder of the outer surface is rough, vertical, and nearly flat. The inner surface forms a considerable part of the high inner margin of the foot, and is convex from above downwards ; on its anterior and lower part may be recognized an impression for the insertion of the tibialis anterior tendon. The under surface of the bone is convex from side to side, and rough for the attachment of ligaments. It will be noticed that in the case of the os cuneiforme primum, the thin end of the wedge is directed upwards towards the dorsum of the foot.

The **os cuneiforme secundum**, or *middle cuneiform*, is the smallest and most distinctly wedge-shaped of the three ossa cuneiformia ; the thin end of the wedge being directed downwards towards the sole of the foot. This bone articulates

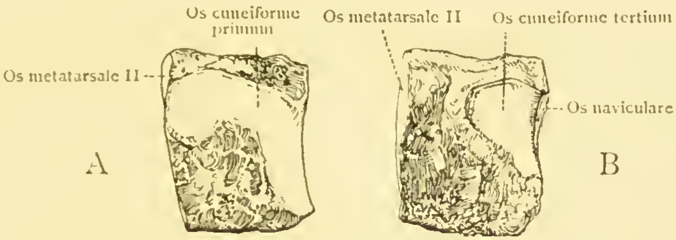

Fig. 91.—A, right os cuneiforme secundum from the inner side ; B, left os cuneiforme secundum from the outer side.

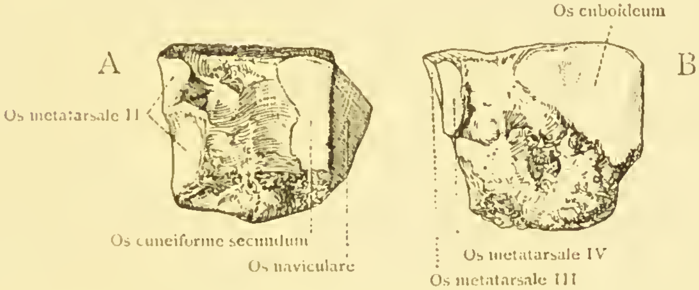

Fig. 92.—A, right os cuneiforme tertium from the inner side ; B, left os cuneiforme tertium from the outer side.

posteriorly with the middle facet on the anterior surface of the os naviculare ; anteriorly, with the base of the os metatarsale of the second toe ; internally, with the os cuneiforme primum ; and externally with the os cuneiforme tertium.

The **os cuneiforme tertium**, or *external cuneiform*, is intermediate in size between the os cuneiforme primum and secundum. As in the latter bone, the thin end of the wedge is directed towards the sole, and the base towards the dorsum of the foot. The outer aspect of the os cuneiforme tertium is easily identified by the presence, on its upper and posterior part, of a large flat facet for the os cuboideum. The outer surface usually bears at its anterior end a very small facet for the os metatarsale of the fourth toe. On the inner side of the bone there are two facets, one posteriorly, for the os cuneiforme secundum, and one anteriorly for the os metatarsale of the second toe. The anterior, or distal end of the bone articulates with the os metatarsale of the third toe; the posterior, or proximal end, with the outer of the three facets on the anterior aspect of the os naviculare.

THE OS CUBOIDEUM.

The **os cuboideum** is distinctly larger than any of the ossa cuneiformia. It lies on the outer part of the foot in front of the calcaneus, behind the ossa metatarsalia of the fourth and fifth toes, and to the outer side of the os cuneiforme tertium. With

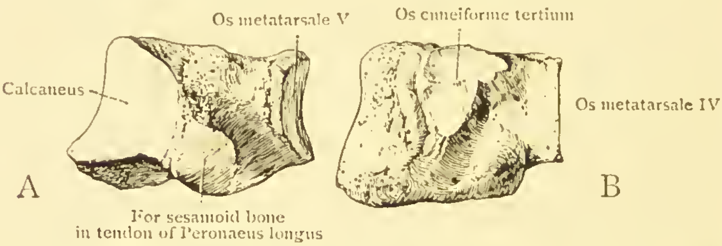

FIG. 93.—A, right os cuboideum from outer side; B, left os cuboideum from inner side.

all of these it articulates. The dorsal aspect is smooth and flat, and slopes downwards and outwards, its inner border being longer than its outer. On its plantar aspect may be seen a thick ridge, in front of which a sulcus for the tendon of the peronaeus longus muscle passes inwards and forwards. The outer end of this ridge is smooth and articular, and is formed by a facet for a sesamoid bone developed in the tendon of the muscle. The ridge gives attachment to the fibres of the ligamentum plantare longum. The largest facet on the os cuboideum is for the calcaneus; it is concavo-convex and its lower edge is very prominent. The facet for the os cuneiforme tertium is flat and lies on the inner surface of the bone near its upper edge; behind it may often be seen a small articular area for the outer edge of the os naviculare. The facets for the fourth and fifth ossa metatarsalia are continuous, and both look outwards as well as forwards.

THE METATARSUS.

The **ossa metatarsalia** are five in number and are named first, second, third, fourth, and fifth, in order beginning at the great toe. In shape, the ossa metatarsalia II–V resemble the ossa metacarpalia II–V, but they are longer and more slender.

The great toe metatarsale is easily identified; it is much thicker and stronger than the others, and than the corresponding bone of the thumb.

The ossa metatarsalia lie close together, nearly parallel to one another, and are firmly united at their proximal ends to the distal row of the ossa tarsalia. The outer four also articulate with one another, and are firmly united by ligaments. The ossa metatarsalia possess less mobility than the corresponding bones in the hand.

As in the ossa metacarpalia, we recognize in each os metatarsale the following:—a **basis**, or proximal end; a **corpus** or *shaft*; and a **capitulum**, *head*, or distal extremity. We shall examine the metatarsalia, omitting at first that of the great toe.

The **corpus**, or *shaft*, is arched so as, in its long axis, to be concave towards the sole, and slightly convex towards the dorsum of the foot. Traced from the basis towards the capitulum the shaft tapers gradually, and it is most slender immediately behind the capitulum. As in the ossa metacarpalia, the sides of the shaft give attachment to the interossei muscles, but there is no marked triangular area on the dorsal aspect of the shaft like that present in the ossa metacarpalia.

The **capitulum** is convex from side to side and from above downwards, and the articular surface extends further on the plantar than on the dorsal aspect. Against it rests the base of the phalanx prima and the cartilaginous plate which closes the metatarso-phalangeal joint on its plantar aspect. On the dorsal aspect of the capitulum, immediately behind the articular area, a little tubercle will be seen on each side for the attachment of the collateral metatarso-phalangeal ligament.

The **bases** of the metatarsalia are flat and rough on their dorsal, and somewhat convex and rough on their plantar aspects for the attachments of ligaments. Figures 83, 94, and 95 indicate the manner in which these bases articulate with one another, and with the distal row of the ossa tarsalia. It will be noticed that the bases of the outer four ossa metatarsalia, when viewed from the dorsal aspect, exhibit an acute angle at the outer side, which is determined by the oblique direction of the line of the tarso-metatarsal joint as it passes from the outer to the inner margin of the foot. The presence and position of this acute angle will enable the student to recognize at a glance to which foot any one of these ossa metatarsalia belongs.

The *os metatarsale of the second* toe is the longest of the series. It is important to notice how firmly its basis is united

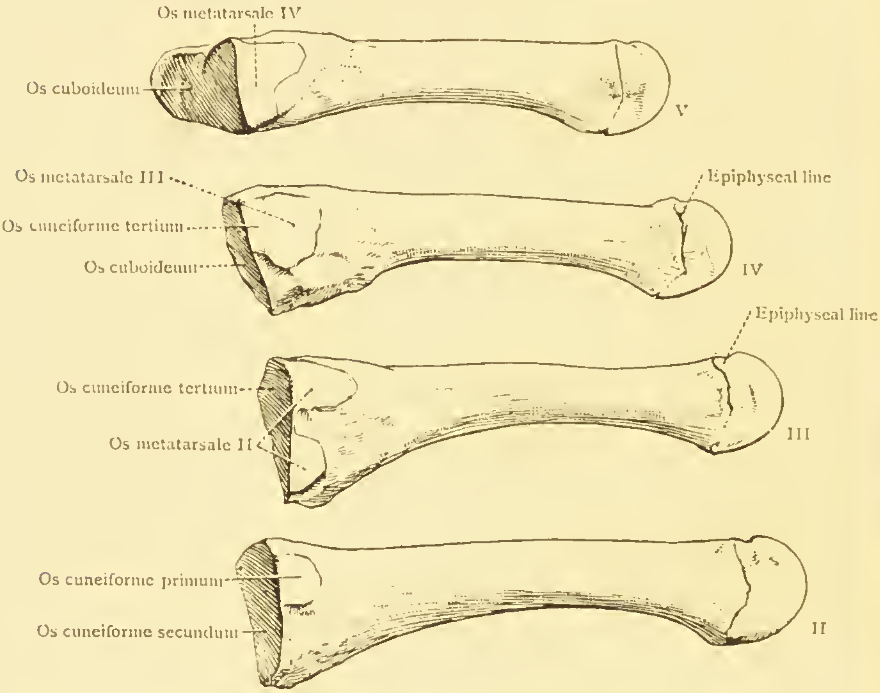

FIG. 94.—Ossa metatarsalia II–V of left foot viewed from the inner side. From a young subject.

with the tarsus; being wedged into a recess bounded by the three ossa cuneiformia. The outer side of its base articulates with the third toe os metatarsale, and with the os cuneiforme tertium; the inner side of its base with the os cuneiforme primum, and sometimes also, by a pressure facet, with the os metatarsale of the great toe. The large facet on the posterior part of the base is in contact with the os cuneiforme secundum.

The *os metatarsale of the third* is almost as long as that of the second toe. Its base articulates on the outer side by a single facet with the fourth, and on the inner side by two smaller facets with the second os metatarsale. Posteriorly the base articulates with the os cuneiforme tertium.

The *os metatarsale of the fourth* toe articulates with the os cuboideum and, to a slight extent, with the os cuneiforme tertium. Each side of the base articulates by a single flat facet with the adjacent os metatarsale.

The *os metatarsale of the fifth*, or little toe, may be at once recognized by the curious spur-like tubercle which projects

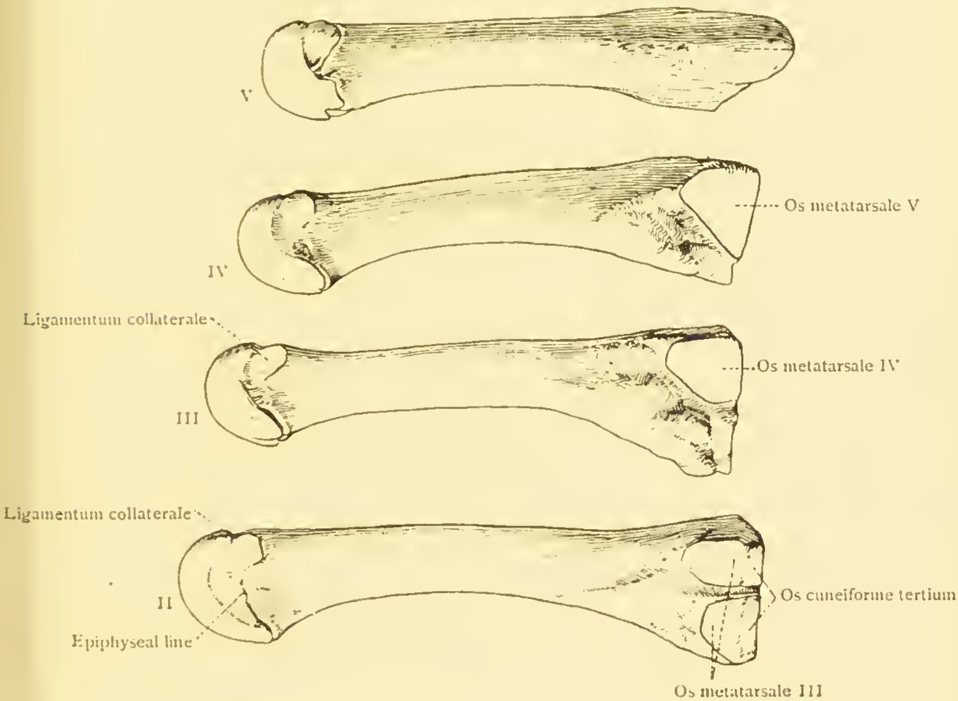

FIG. 95.—Ossa metatarsalia II–V of left foot viewed from the outer side. From a young subject.

outwards and backwards from the outer angle of its base. This tubercle, the **tuberositas ossis metatarsalis** V, gives insertion to the tendon of the peronaeus brevis muscle, and forms an important landmark at the outer edge of the foot, where it may be easily felt in the living subject (see fig. 88).

The *os metatarsale of the first*, or great toe is shorter and much stouter than the others, and its shaft, when viewed from the dorsal aspect, does not taper towards its distal end. The proximal aspect of the basis shows a large, somewhat kidney-shaped facet for the os cuneiforme primum ; and its flattened outer aspect often bears a pressure facet for the inner side of the base of the os metatarsale of the second toe. On the under and outer part of the basis, there is an impression which marks the insertion of the strong tendon of the peronaeus longus. A part of the tendon of the tibialis anterior is inserted into the convex inner aspect of the base.

The shaft is flat on its outer, and convex on its inner aspect: the former gives origin to the first dorsal interosseus muscle. The articular surface on the large capitulum articulates with the base of the phalanx prima of the great toe, and also, by

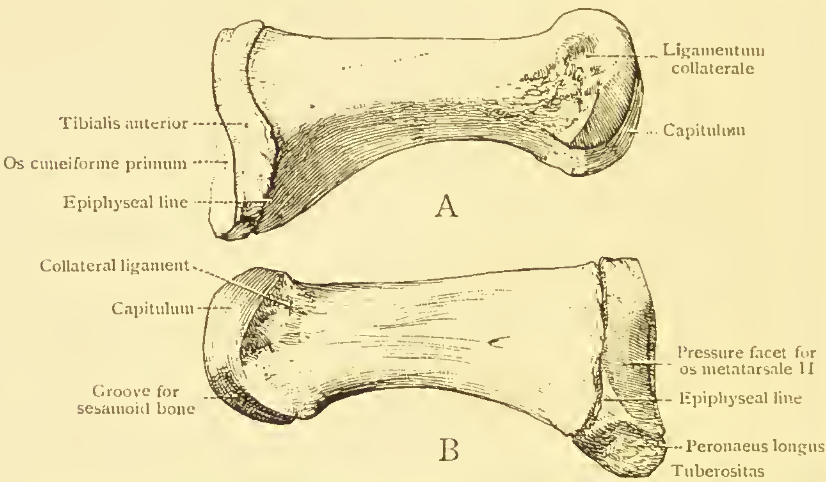

Fig. 96.—Os metatarsale of the great toe of the left foot; A, from the inner, and B, from the outer aspect. From a young subject.

two smooth grooves on its plantar aspect, with sesamoid bones which lie beneath the metatarso-phalangeal joint in the tendons of the flexor hallucis brevis muscle.

THE PHALANGES.

The **phalanges** of the toes are arranged in a similar manner to those of the fingers. In the toes, however, the phalanges are much shorter than in the hand, and this difference is especially marked in the case of the phalanx secunda and tertia in each toe.

In each **phalanx prima** we have the oval concave proximal facet for the capitulum of the os metatarsale; the trochlear distal facet for the phalanx secunda; the convex dorsal and the flat plantar aspect of the shaft. The latter has sharp edges for the attachment of the flexor sheath. In all these particulars we note an agreement in the form of a phalanx prima of a toe with that of a finger.

In the outer toes the length of the **phalanx secunda** does not much exceed the width; and in the case of the little toe the phalanx secunda is often fused to the phalanx tertia. As in the hand, the proximal end of the phalanx secunda shows two little concavities for articulation with the distal end of the

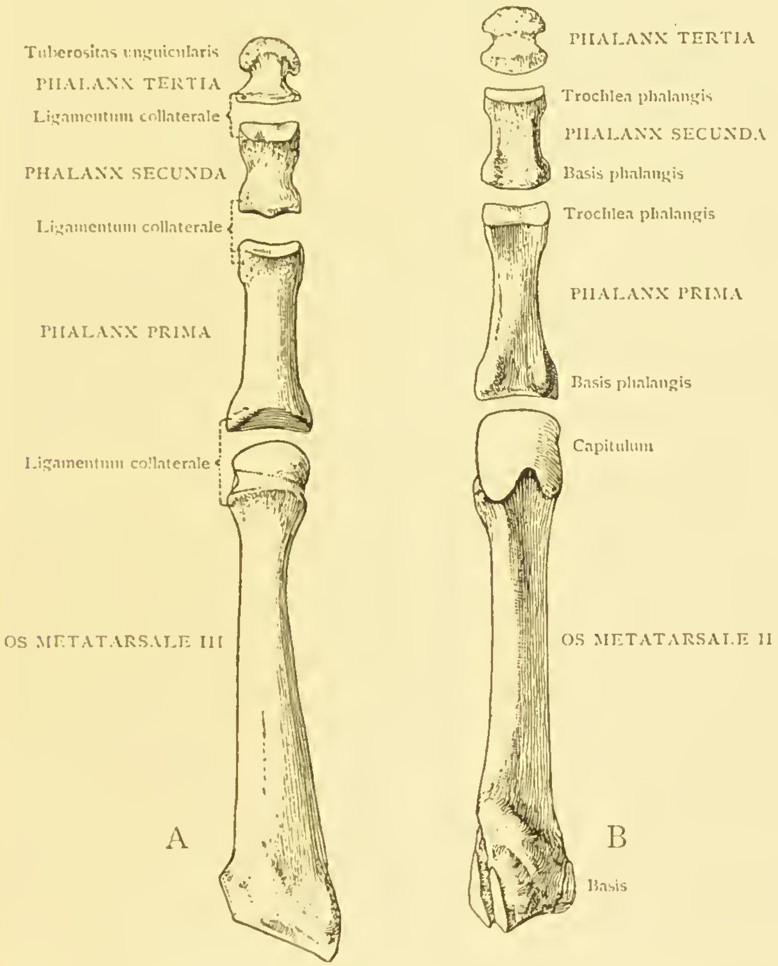

FIG. 97.—A, os metatarsale and phalanges of the third toe of the right foot seen from the dorsal aspect; B, os metatarsale and phalanges of the second toe of the right foot from the plantar aspect.

phalanx prima, and the distal end of the phalanx secunda has a trochlear surface for the base of the phalanx tertia.

The **phalanx tertia** is very small and ends in a flattened extremity, as in the fingers.

In the *great toe* the phalanx prima is a strong, stout bone, and the phalanx secunda, which forms the termination of the great toe, is strong and large in proportion to the phalanges of the other toes.

THE FOOT AS A WHOLE.

Having surveyed its component parts, the student should again examine the foot as a whole from its inner, outer, plantar, and dorsal aspects.

Viewed from its *inner side*, the *arch of the foot* is well seen. The keystone of the arch is formed by the talus; the short posterior pillar by the calcaneus; and the inner side of the long anterior pillar by the os naviculare, os cuneiforme primum, and the stout os metatarsale of the great toe. The manner in which the sustentaculum tali assists in supporting the talus, and the area on the head of the latter bone which during life rests against the ligamentum calcaneo-naviculare plantare, are well seen. It should be noticed that the tuberositas ossis navicularis lies immediately in front of the portion of the caput tali which is exposed in the dry skeleton, and in the living foot this projecting tubercle is used by the surgeon as a guide to the position of the talo-navicular articulation. Before completing the survey of the inner side of the foot, the insertion of the tibialis posterior and of the tibialis anterior should be recognized; the former is attached to the tuberositas ossis navicularis and to the os cuneiforme primum, and the latter to the os cuneiforme primum and to the os metatarsale of the great toe. The sulcus formed on the talus and on the sustentaculum tali for the flexor hallucis longus, and the great hollow on the inner side of the calcaneus for the transmission of the vessels, nerves, and tendons to the sole of the foot should be examined.

The *outer border* of the foot is by no means so distinctly arched as the inner. It is formed by the calcaneus, the os cuboideum and the os metatarsale of the little toe. The student should not fail to recognize the following points:—the wide opening of the sinus tarsi; the flatness of the outer aspect of the calcaneus; the position occupied by the peronaei tendons in relation to the calcaneus; the beginning of the groove for the peronaeus longus, and the facet for the sesamoid bone on the os cuboideum; and the spur-like tuberositas on the base of the os metatarsale of the little toe. This latter is used as a guide to the common metatarso-phalangeal articulation in the living foot.

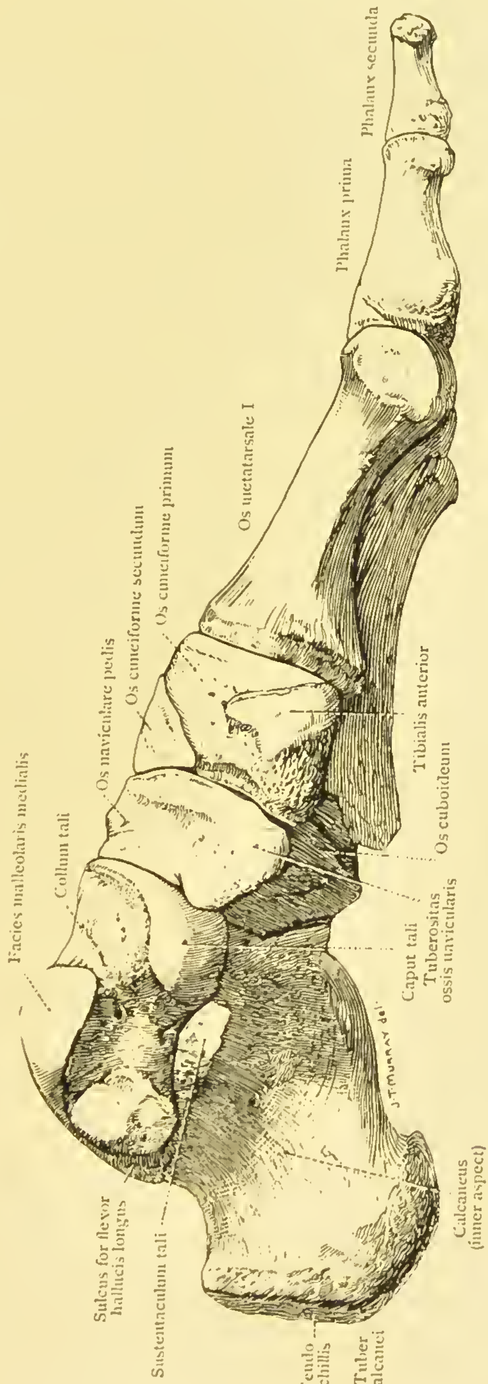

FIG. 98.—Left foot from the inner side.

An examination of its plantar aspect shows the foot to be arched not merely in a longitudinal, but also in a transverse direction. The wedge-like nature of the ossa cuneiformia secundum and tertium should be noticed. The formation of these bones will be found to be largely responsible for the transverse arch of the foot. The position of the *transverse tarsal articulation* should be recognized. This articulation lies behind the os cuboideum and the os naviculare, and in front of the calcaneus and the talus. When seen from below, it will be readily understood that the transverse tarsal articulation is most easily opened at the inner side of the foot by cutting immediately behind the plane of the tuberositas ossis navicularis. The inward and forward direction of the ridge and groove on the os cuboideum should be noted. The plantar aspects of most of the tarsal bones are rough for the attachment of strong ligaments and for slips from the tendons of the muscles which reach the sole of the foot. These ligaments and tendons are of great importance in uniting the bones, and for maintaining the arch of the foot. When the foot rests evenly upon the ground the weight of the body is transmitted through the calcaneus and the ossa metatarsalia.

When examining the foot from its *dorsal aspect*, the backward projection of the calcaneus, the plane of the mid-tarsal articulation, and of the tarso-metatarsal joint should again be noticed. The close fitting of the ossa cuneiformia, and the connexions of the basis of the os metatarsale of the second toe should be examined. The manner in which the latter is enclosed between the extremities of the ossa cuneiformia primum and tertium should be studied. The side to side convexity of the dorsum of the foot is very apparent.

THE ANKLE-JOINT AND THE MOVEMENTS OF THE FOOT.

The trochlea of the talus should again be studied, and the manner in which it is received into the fossa formed by the under aspect of the tibia and the two malleoli carefully examined. By articulating the dry bones at the ankle-joint some idea of the movements which take place during life may be obtained. When standing, the axis of the foot is at right angles to the axis of the leg. When the heel is depressed and the toes are raised the movement is spoken of as dorsi-flexion; when the heel is lifted and the weight of the body is borne by the toes, the ankle is said to be extended, or plantar-flexed. The horizontal axis round which the foot moves does not lie at right angles to the middle line, but is directed outwards and back-

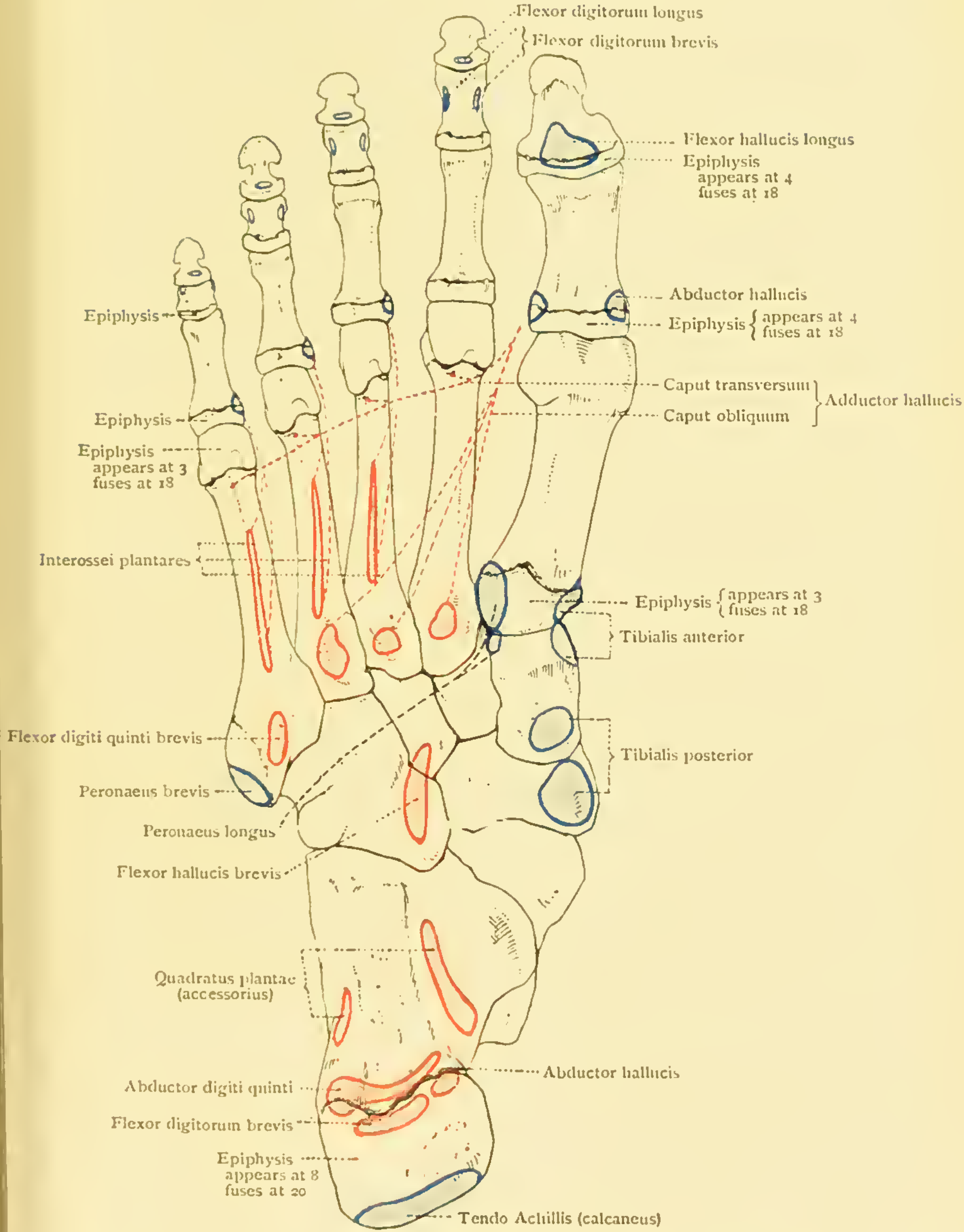

FIG. 99.—Right foot seen from the plantar aspect. From a subject aged about 17 years. The chief attachments only of the muscles are shown.

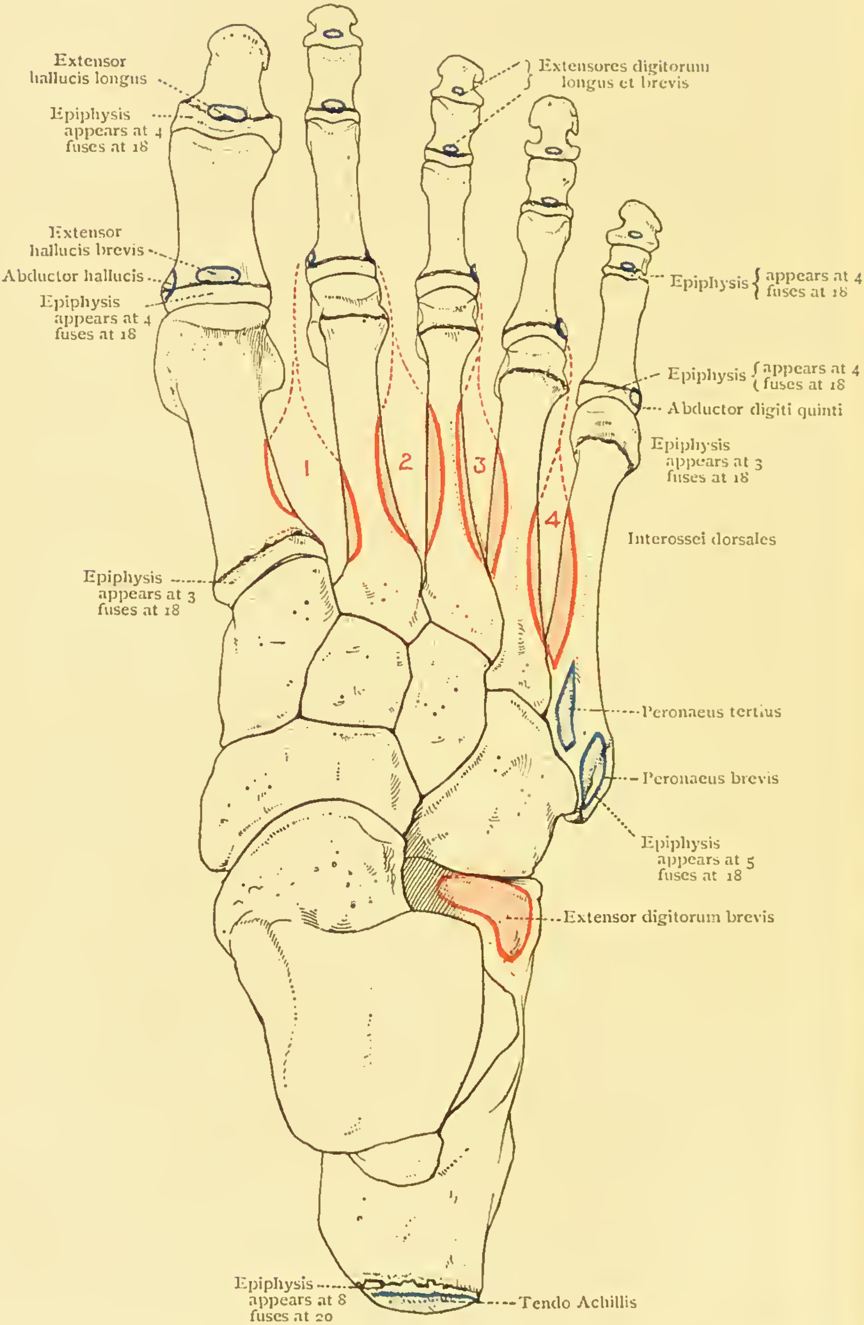

FIG. 100.—Right foot seen from the dorsal aspect. From a subject aged about 17 years.

wards. It is probable that in spite of the narrower transverse diameter of the posterior part of the trochlea tali, very little or no side movement, adduction and abduction, normally occurs at the ankle, even in the extended condition of the joint.

Gliding movements between the tarsal bones, especially in the talo-calcaneal and mid-tarsal joints, are responsible for adduction and abduction of the foot, and also for inversion and eversion. In inversion the inner edge of the foot is raised so that the sole looks inwards; in eversion the outer edge of the foot is raised and the sole is directed slightly outwards.

The movements of the toes are very similar to those of the fingers, but much more limited.

THE SKULL.

In his study of the skull the student is advised in the first instance to examine the entire skull from above, from the side, and from below; then to study the inner aspect of the cranium in a specimen in which the roof, or calvaria, has been removed, and also in a skull cut in mesial section. The latter form of section gives an excellent opportunity for the investigation of the parts relating to the nose. During this examination, he should have at hand the isolated bones of a disarticulated skull, so that he may appreciate the share taken by each component part in the building up of the entire skull.

The skull may be divided into an upper and posterior portion, or *cranium*, somewhat globular in outline, which encloses, and forms the protecting cavity for the brain; and an anterior and lower portion which forms the skeleton of the *face*. Both these subdivisions are composed of numerous separate bones firmly and immovably united together, except in the case of the lower jaw, or mandible. The lines of union are spoken of as **suturae**, and are well seen in skulls that have not yet reached middle age; in old people they tend to become obliterated, as many of the component bones of the skull fuse together. It is best to begin the study of the skull upon a young specimen in which the lines of the suturae are distinct, as it is only by a study of their arrangement that it is possible to map out the various bones of the cranium and of the face. For the most part the lines of the suturae run very complicated courses; the bones which they unite being highly irregular in outline, and interlocking along their edges in a very remarkable manner.

THE SKULL FROM ABOVE.

Having selected a suitable skull, the student should hold it so that the large opening on the under aspect, or **foramen occipitale magnum**, is directed downwards, and the sockets for the eyes, or **orbitae**, look forwards. When the skull is held in this position and viewed from above—*norma verticalis*—it presents an ovoid outline; its greatest transverse diameter lying nearer to the back than to the front of the head.

Two well-marked suturae will be seen to map out three areas on this aspect of the skull. One of these, the **sutura coronalis**, crosses the skull in a transverse direction in front of its middle point and maps off the **os frontale**, which forms the front portion of the cranial roof. The other suture, named **sutura**

FIG. 101.—Skull from above.

sagittalis, occupies the middle line and extends backwards from the middle point of the sutura coronalis. It separates the left from the right **os parietale**, and ends posteriorly by joining the **sutura lambdoidea** which marks the anterior limit of the **os occipitale**. As a rule but little of the latter suture can be seen unless the skull is tilted slightly forwards, and when this is done a better view of the upper part of the os occipitale is obtained. The bones just mentioned form the skull cap, or **calvaria**, which is sawn off when the brain is removed for post-mortem examination.

The point where the sutura sagittalis meets the sutura coronalis is called the *bregma*, and the student will recognize that the arch of the calvaria is sometimes very slightly flattened in this region.

Just in front of the *lambda*, or point where the sutura lambdoidea is joined by the sutura sagittalis, there is a more decidedly flattened area on the arch of the calvaria, which can usually be recognized in the head of the living subject. On this flattened area there may often be noticed a small opening, the **foramen parietale**, on each side of the suture, through which a vein passes from the scalp to join the sinus sagittalis superior, or superior longitudinal blood sinus, within the cranium. It is a curious fact that the suture as it traverses the flattened area immediately in front of the lambda is straighter, and often decidedly less complicated in its course than elsewhere.

The most convex part of the parietal bone is spoken of as the **tuber parietale**, or *parietal eminence*, and in the young skull it forms the most lateral part of the cranium; in older specimens the greatest width is usually at a lower level.

It is important to notice that the sutura coronalis is not accurately transverse, but that its direction on each side is downwards and forwards. The suture is crossed by a pair of lines, known as the **lineae temporales**, which indicate the upper limit of the temporal muscle, and are continued backwards on to the parietal bone. They are best seen when the skull is viewed from the side; the point where they cross the sutura coronalis is named the *stephanion.* The surface of the cranial wall between the lineae temporales of opposite sides is covered only by the layers of the scalp.

THE SKULL FROM THE SIDE.

The skull should now be viewed from the side—*norma lateralis*—and the markings already identified should be noted as they appear from this aspect.

It will be seen that the arch formed by the calvaria is practically a semicircle; and the shares taken by the os frontale, os parietale, and os occipitale in its formation may be readily estimated. The uniformity of the curvature of the cranial vault is slightly interrupted at the bregma, and in the region of the lambda, where, as we have already seen, slight flattening occurs.

Just over the depression at the root of the nose there is a forward bulging known as the **glabella**, which is better seen when the skull is viewed from in front. The point on

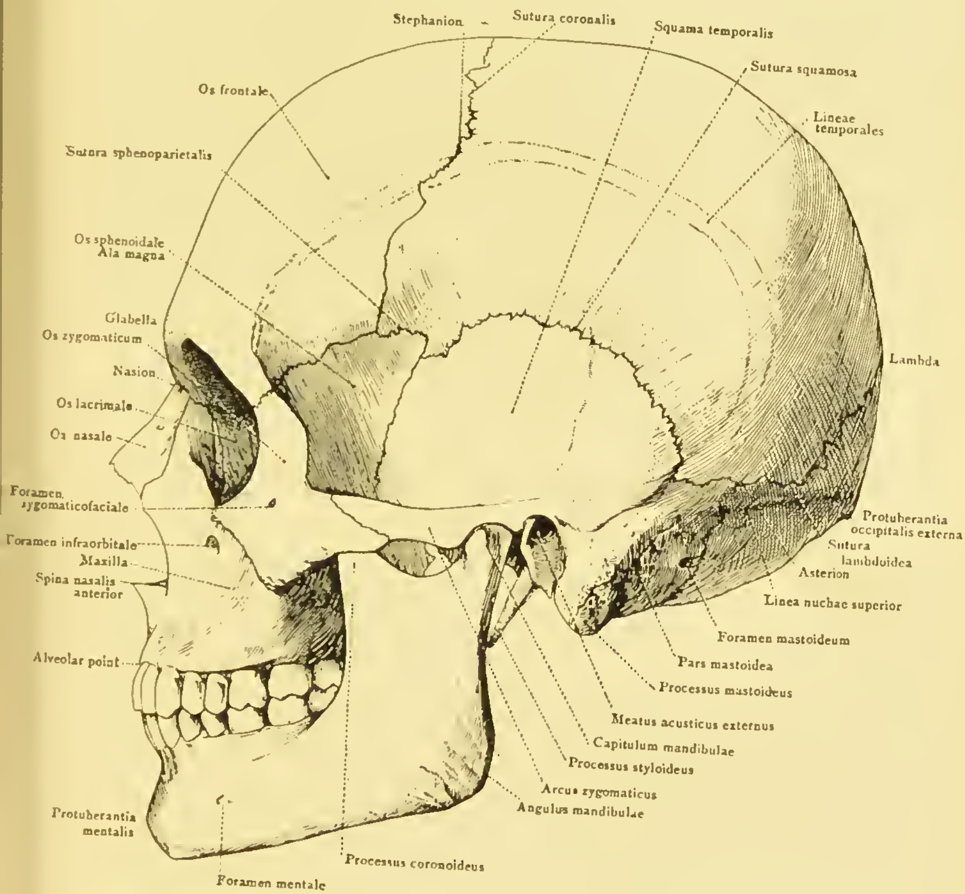

FIG. 102.—Skull from the left side.

the cranial wall most distant from the glabella is known as the *occipital point.* It lies below the lambda at a short distance above a variably developed projection, the **protuberantia occipitalis externa**, *external occipital protuberance*, or *inion.* This latter is a most important landmark, and its position can be made out in the living subject in the middle line, at the back of the head, where the neck joins the scalp.

The **os parietale** takes the largest share in the formation of the roof and side wall of the cranial cavity. In outline it is approximately quadrilateral, and its four borders correspond to the most strikingly marked sutures of the cranial wall. At its upper border, or **margo sagittalis**, is the sutura sagittalis which separates the os parietale from the bone of the opposite side ; at its anterior border, or **margo frontalis**, lies

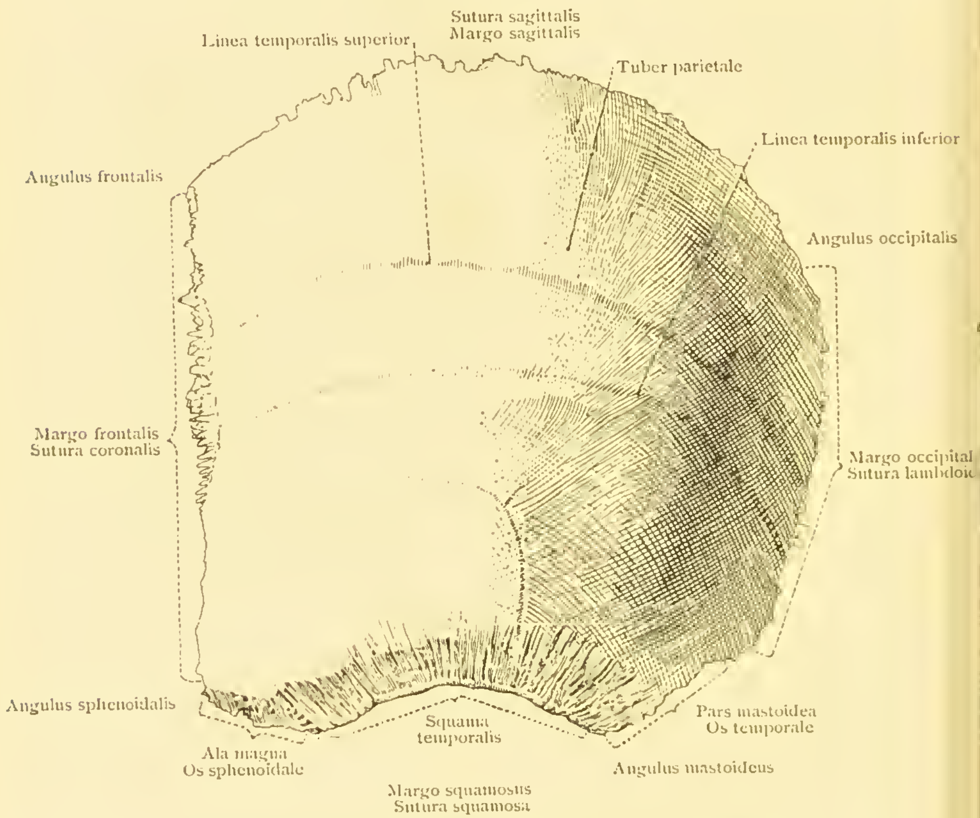

FIG. 103.—Left os parietale from the outer aspect.

the sutura coronalis which divides it from the os frontale. Behind its posterior border, or **margo occipitalis**, is the sutura lambdoidea, where the os parietale joins the os occipitale ; and along its lower edge lies an irregularly curved suture, the middle and greater part of which is completed by the **squama temporalis**. The anterior part of the lower border of the os parietale articulates with the **ala magna** of the **os sphenoidale** ; the posterior part joins the **pars mastoidea** of the **os temporale.** The complex articulation along the lower edge of the os parietale may therefore be divided into three portions named sutura spheno-parietalis, sutura squamosa, and sutura parieto-mastoidea, in order from before backwards. It will be noticed that at the sutura squamosa and the sutura spheno-parietalis, the lower border of the os parietale is overlapped to a very considerable extent by the squama temporalis and by the ala magna of the os sphenoidale.

The position of the angles of the os parietale should now be noted : the upper and anterior angle, or **angulus frontalis,** lies at the bregma ; the upper and posterior angle, or **angulus occipitalis,** is situated at the lambda ; the lower and anterior angle, or **angulus sphenoidalis,** fits into the angular interval between the os frontale and the ala magna of the os sphenoidale; and the lower and posterior angle, or **angulus mastoideus,** which is ill-defined, lies at the sutura parieto-mastoidea. In the skull of an infant at birth the bony wall of the cranium is deficient in the region of each of these angles, and the brain is covered merely by its membranes and the layers of the scalp (see fig. 172). The region where the angulus sphenoidalis articulates with the ala magna of the os sphenoidale is spoken of as the *pterion.*

Curving over the outer aspect of the parietal bone will be seen two parallel lines separated by a narrow interval. The lower of these, or **linea temporalis inferior,** marks the upper limit of the origin of the powerful temporal muscle; the upper, or **linea temporalis superior,** gives attachment to a strong layer of fascia, the fascia temporalis, which covers the muscle and affords origin to many of its fibres.

It will be noticed that the linea temporalis superior is continued in front, across the sutura coronalis on to the frontal bone; and posteriorly, over the junction of the sutura squamosa with the sutura parieto-mastoidea, on to the os temporale. In the latter part of its course it forms a ridge, sometimes strongly marked, and spoken of as the *supramastoid* crest.

The large area on the side of the cranium which is limited above, in front, and behind by the linea temporalis, is known as the **fossa temporalis,** and affords origin over the whole of its extent to the temporal muscle. If the fossa temporalis be examined it will be found that its floor is formed by the squama temporalis, a considerable portion of the os parietale, a part of the ala magna of the os sphenoidale, and a small part of the os frontale.

The linea temporalis superior becomes more distinct as it is traced forwards and downwards on to the os frontale, and a short distance behind the upper and outer part of the orbital cavity, it passes downwards and slightly backwards and becomes continuous with the free posterior border of the **os zygomaticum**, or *malar bone*, which is interposed between the orbital cavity in front, and the fossa temporalis behind. The posterior border of the os zygomaticum is continued downwards to the upper edge of a remarkable flying buttress of bone which passes horizontally backwards, on the outside of the skull, to the region just above and in front of the external ear-hole. This buttress, called the **arcus zygomaticus**, or *zygomatic arch*, is formed partly by the os zygomaticum and partly by the **processus zygomaticus** of the os temporale. The upper edge of the arcus zygomaticus is continued by a ridge above the external opening of the ear, or **meatus acusticus externus**, to the supramastoid crest, and through it to the linea temporalis.

It is thus possible to trace a connexion between the anterior and posterior ends of the linea temporalis, through the posterior border of the os zygomaticum, the upper edge of the arcus zygomaticus and the supramastoid crest; and at the same time the continuous line of attachment of the strong fascia temporalis, which roofs over the fossa temporalis, will have been followed.

The wide interval between the arcus zygomaticus and the side of the cranium readily admits the tips of two fingers, and through it the temporal muscle passes downwards to reach its insertion into the **processus coronoideus** of the **mandibula**. The further study of the arcus zygomaticus will be undertaken later on (page 185).

The smooth surface of the cranial wall which lies above, behind, and in front of the fossa temporalis, is covered only by the layers of the scalp. The area extends forwards, to the glabella and almost to the upper margin of the orbital opening; backwards, to the protuberantia occipitalis externa and the curved rough line which arches outwards and forwards from it. The latter line is best seen when the skull is viewed from behind, and is known as the **linea nuchae superior**, or *superior curved line* of the occipital bone; it defines the upper limit of the attachment of the muscles of the neck to the posterior part of the skull.

The part of the cranial wall which we have examined, lies above a line drawn from the protuberantia occipitalis externa, along the linea nuchae superior to a point just above the meatus acusticus externus, then along the upper border of the arcus zygomaticus, and upwards, behind the posterior free border of the os zygomaticum, and finally forwards and inwards, parallel to the upper margin of the orbital opening, to a point on the glabella. The line thus roughly indicated is important, as it maps out the lower border of the cerebrum. All the cranial wall which lies above it is related to the convex outer surface of the cerebral hemisphere. It is important to recognize that the bony points necessary to determine the position of the line in question can be identified in the living subject, thus enabling the outline of the cerebrum to be drawn with considerable accuracy on the surface of the head.

Below the level of the linea nuchae superior, the wall of the cranium is formed by the lower part of the os occipitale and by the pars mastoidea of the os temporale, and covers the cerebellum. Many of the markings on this part of the cranial wall are best seen when the skull is examined from behind and below.

The passage of the ear, or **meatus acusticus externus,** may next be examined. It lies in the os temporale immediately behind the articulation formed between the skull and the lower jaw, and it is bounded by a scroll-like plate of bone which is bent round it to form the short tube of the meatus. This plate of bone is known as the **pars tympanica**, or *tympanic plate*, of the os temporale. Its free edge surrounds the opening of the meatus, and is rough and irregular for attachment of the cartilaginous portion of the external meatus which leads to the surface in the living head. It will be noticed that the passage is oval in section, its long axis being nearly vertical, and that the direction of the passage is forwards and inwards.

In the living head, the membrana tympani lies at the bottom of the meatus, and separates the external ear from the middle ear, or **cavum tympani**. In the macerated skull the membrana tympani has disappeared, and it is possible to see the inner wall of the cavum tympani, by looking into the meatus. By adjusting the skull to the proper angle and looking through the meatus, the student will probably be able to identify a slight bony prominence and two minute foramina. The prominence is known as the **promontorium** and is caused by the outward bulging of the **cochlea**, a portion of the internal ear, and the foramina are named **fenestra vestibuli** or *ovalis*, and **fenestra cochleae** or *rotunda*; in the dry bone they both lead from the cavum tympani into the cavity of the internal ear, but during life the fenestra ovalis, which is the higher up, is occupied by the footplate of the **stapes**, one of the ear ossicles, and the fenestra rotunda is closed by membrane.

Behind the opening of the ear a blunt conical process projects downwards, and is adherent to the posterior wall of the meatus acusticus externus. The apex of this important process, known as the **processus mastoideus**, lies, in the adult, below and behind the meatus externus, and can be easily felt

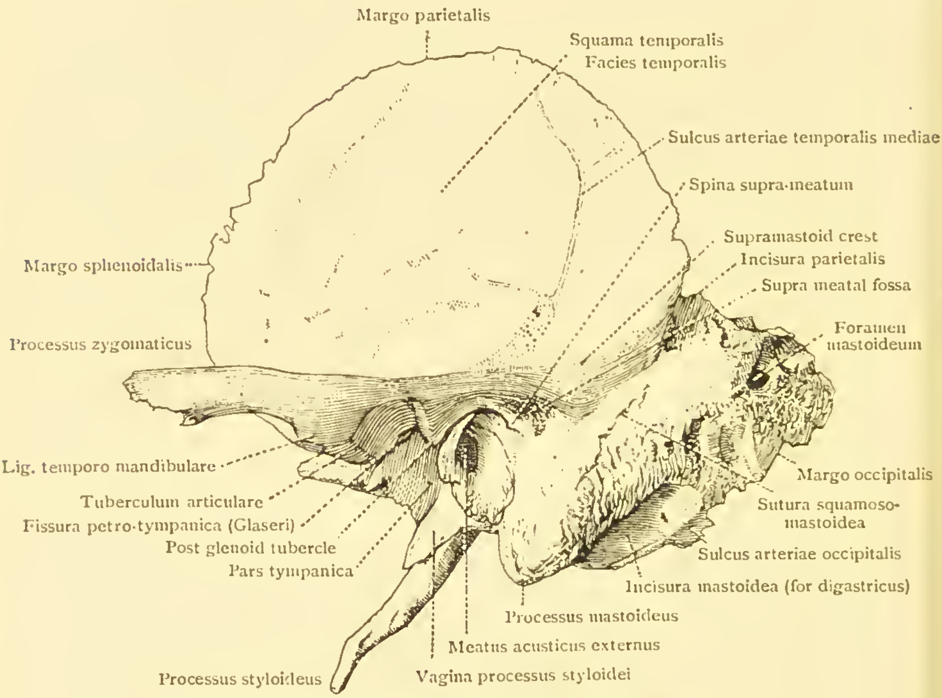

FIG. 104.—Left os temporale from the outer side.

in the living subject. The outer aspect of the process, with which for the moment we are alone concerned, is convex and rough, and gives insertion to some important muscles which reach it from the neck: viz. sterno-cleido-mastoideus, splenius capitis, and longissimus capitis (or trachelo-mastoid).

Sometimes the interrupted remains of a suture, the **sutura squamo-mastoidea**, which indicates the line of fusion of the primitive squama temporalis with the pars mastoidea of the os temporale, may be recognized a short distance behind the meatus acusticus running downwards and forwards on the outer aspect of the bone. It should be noticed that the line of this suture is not used in the adult to indicate the separation of the part called squama from the pars mastoidea, but that all the os temporale which appears on the outside of the skull, behind the meatus and below the posterior part of the fossa temporalis is regarded as pars mastoidea.

In many cases a foramen will be recognized in the pars mastoidea of the os temporale, behind and above the mastoid process and close to the sutura occipito-mastoidea. This, the **foramen mastoideum**, is often of small size and, when present, transmits a vein which joins the sinus transversus, or lateral sinus, within the cranial cavity.

A slight depression behind the upper part of the meatus and immediately below the supra-mastoid ridge, which bounds the temporal fossa in this position, is of great surgical importance. It is spoken of as the *supra-meatal fossa*, or triangle, and its anterior limit is sometimes indicated by a minute **spina supra-meatum.**

The **antrum tympanicum**, or *mastoid antrum*, a small cavity which communicates with the cavum tympani in front, and with the air cells contained in the processus mastoideus posteriorly, is reached by the surgeon through the floor of the supra-meatal fossa. In the adult the little cavity lies at a depth of nearly half an inch from the surface of the bone (see page 297).

By looking into the interval between the mandible and the processus mastoideus, the long slender **processus styloideus** can be seen projecting downwards and forwards. This process is very liable to be broken off, and in some cases it may be normally represented by a separate piece of bone. It gives origin to a number of muscles, viz. stylo-glossus, stylo-hyoideus, and stylo-pharyngeus, and also to a ligament which connects its tip to the hyoid bone. The position of the processus styloideus, not only with regard to the processus mastoideus, but also to the meatus acusticus externus, should be recognized.

We have already noticed that as the **arcus zygomaticus** passes forwards, at some distance from the outer wall of the cranium, its upper thin border runs a horizontal course and gives attachment to the fascia temporalis, and is continued posteriorly, above the meatus acusticus externus, into the supra-mastoid crest and through it into the linea temporalis. The lower border of the arcus zygomaticus in its anterior two-thirds is thick and rough, and as it is traced forwards, slopes slightly downwards. It and the whole of the deep surface of the arcus zygomaticus give origin to the fibres of the powerful masseter muscle. The outer surface of the arcus zygomaticus is crossed by the **sutura zygomatico-temporalis**, which marks the junction of the processus zygomaticus of the os temporale with the os zygomaticum. The suture is directed downwards and backwards, and in consequence of its direction,

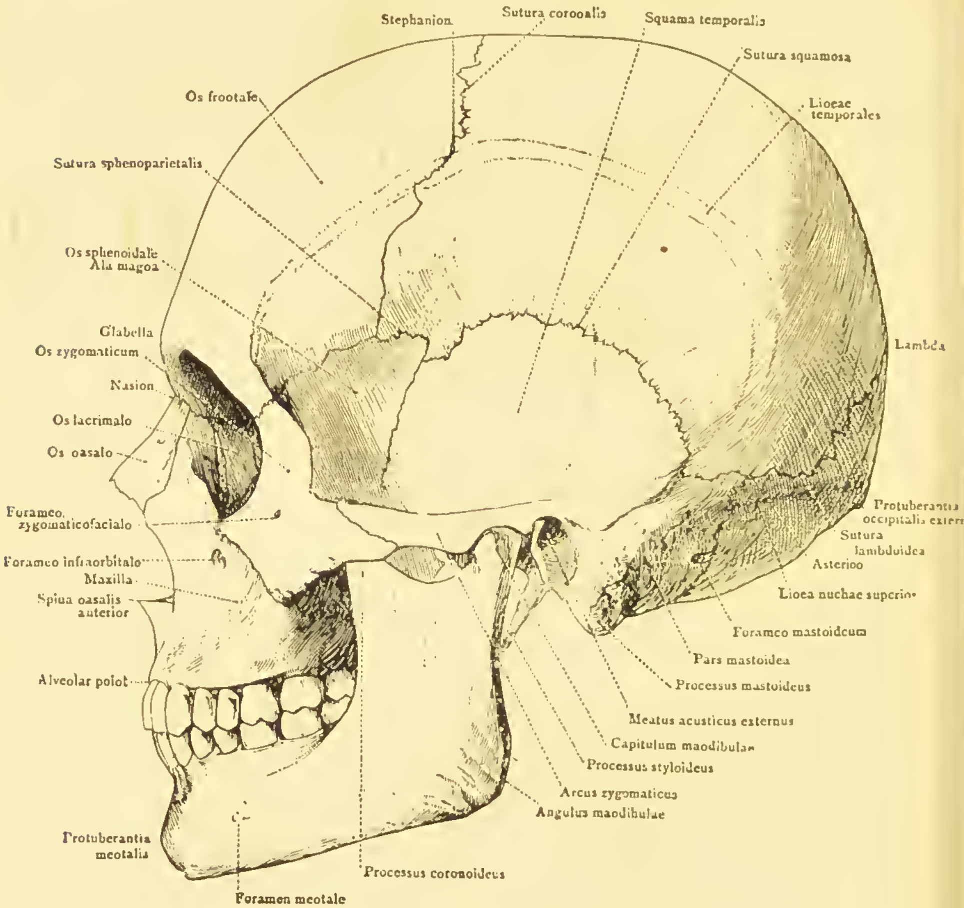

FIG. 105.—Skull from the left side.

the longer part of the upper border of the arcus is formed by the os temporale, and the longer part of the lower border, by the os zygomaticum.

Immediately in front of the **fossa mandibularis**, or *glenoid fossa*, which forms the socket for the mandible, the lower border of the arcus zygomaticus turns slightly downwards, and if the skull be tilted it will be seen that from the inner side of this part of the processus zygomaticus a strong piece of bone passes inwards to join the cranial wall. This may be regarded as the *root of the processus zygomaticus*, and exhibits an upper aspect which looks towards the temporal fossa; and a lower surface which is convex from before backwards, smooth and articular. This convex articular area, known as the **tuberculum articulare**, or *eminentia articularis*, is of great importance in connexion with the movements of the mandible. When the mandible is depressed, as in opening the mouth widely, or when the chin is thrust forwards, the **capitulum mandibulae**, or *head* of the lower jaw, with its inter-articular cartilage slips forwards on to this articular eminence. The strong ligamentum temporo-mandibulare, or external lateral ligament of the lower jaw, is attached to the outer surface and lower border of the arcus zygomaticus, in the region of the tuberculum articulare.

The **fossa mandibularis**, or *glenoid fossa*, which lies behind the tuberculum articulare, extends so far backwards that it is only separated from the meatus acusticus externus by the thickness of the tympanic plate. All the posterior part of the fossa which is formed by the pars tympanica is non-articular, and lodges a part of the parotid salivary gland. When the skull is examined from below a well-marked fissure will be seen to separate the articular from the non-articular part of the fossa mandibularis (see page 213).

The **os zygomaticum**, or malar bone, when viewed from the outer side, has a somewhat quadrilateral outline. One portion, *frontal process*, ascends between the orbital and temporal fossae to reach the os frontale above; another portion, the **processus temporalis**, extends backwards and unites, as we have seen, with the processus zygomaticus of the os temporale; a third, more massive portion, passes inwards and forwards, and joins the maxilla. The upper and anterior, or *orbital margin* of the os zygomaticum is free, smooth and rounded, and forms the outer part of the rim of the orbital opening. The upper and posterior, or *temporal border* is also free, overhangs the fossa temporalis, and gives attachment, as we have seen, to the fascia temporalis. The lower border is the longest and may be divided into an anterior *maxillary part* which is united by the **sutura zygomatico-maxillaris** to the maxilla, and a posterior *masseteric portion* which is free and rough for the origin of the masseter muscle. By passing a finger behind, or in front of, the frontal process of the os zygomaticum, the student will readily recognize the existence of a curved plate, which springs from the deep aspect of the os zygomaticum and lies between the orbit and the fossa temporalis. This plate, called the *orbital process*, is united in its upper part with the ala magna of the os sphenoidale, and in its lower part with the maxilla.

The **facies malaris**, or outer aspect, of the os zygomaticum is subcutaneous and forms the prominence known as the 'cheek-bone'. On it may be seen a minute foramen, called the **foramen zygomatico-faciale.** If a thin bristle be passed into this foramen it is led by a fine canal to an opening, the **foramen zygomatico-orbitale**, on the **facies orbitalis**

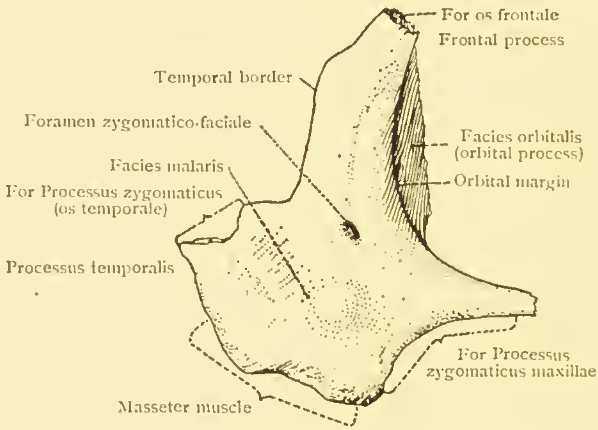

FIG. 106.—Right os zygomaticum from the outer side.

of the orbital process. From this latter opening another minute canal leads to a small foramen, the **foramen zygomatico-temporale**, on the temporal aspect of the orbital process. Thus it can be shown that the os zygomaticum is traversed by two minute canals, having a common origin on the facies orbitalis of the orbital process; one ending on the facies malaris, and the other on the temporal aspect of the orbital process. These canals are traversed, during life, by cutaneous branches of the maxillary division of the nervus trigeminus.

The inner surface, or **facies temporalis**, of the os zygomaticum looks into the fossa infra-temporalis.

Of the bones of the skull, parts of which we have already examined, the os zygomaticum alone takes no share in the formation of the cranial cavity. It is essentially a bone of the face.

The **maxilla**, with which the os zygomaticum is so firmly articulated, forms the largest part of the facial portion of the skull. It occupies the entire interval between the cavity of the orbit and the teeth; and to the inner side of the orbit it reaches as high as the frontal bone. Below the opening of the nose, and above that of the mouth, the maxilla reaches the middle line and articulates with its fellow of the opposite side.

The main portion of the maxilla lies immediately below the orbit and is known as the **corpus maxillae**. It looks strong and massive, but in reality it is hollowed out by a large cavity, the **sinus maxillaris**, or *antrum of Highmore* which, as we shall see, opens into the nasal cavity and is lined by a mucous membrane continuous with that of the nose (see fig. 137).

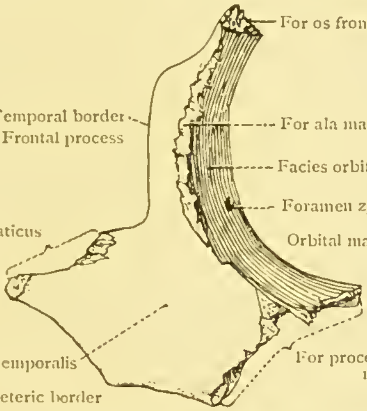

FIG. 107.—Left os zygomaticum from the inner aspect.

The part of the maxilla which supports the os zygomaticum forms a strong projection, the **processus zygomaticus**, and springs from the upper and outer part of the corpus maxillae.

In front of this process lies the **facies anterior** of the maxilla, upon which, a short distance below the margin of the orbit, a large foramen will be seen. This, the **foramen infra-orbitale**, is the termination of a canal, the **canalis infra-orbitalis**, which begins far back in a groove on the floor of the orbit and transmits the large nervus infra-orbitalis. The nerve is the continuation of the maxillary division of the nervus trigeminus and is accompanied by a small infra-orbital artery.

Behind the processus zygomaticus, the surface of the corpus maxillae, here called the **facies infra-temporalis**, looks backwards into a deep hollow which lies under the shelter of a part of the mandible and of the arcus zygomaticus. This hollow, situated below the cranial floor and below the level of the fossa temporalis, is called the **fossa infra-temporalis**, or *zygomatic fossa*. Later on we shall study the infra-temporal fossa in more detail and notice its connexions with other fossae.

The lower part of the maxilla is formed by a curved mass of bone which projects down below the level of the hard

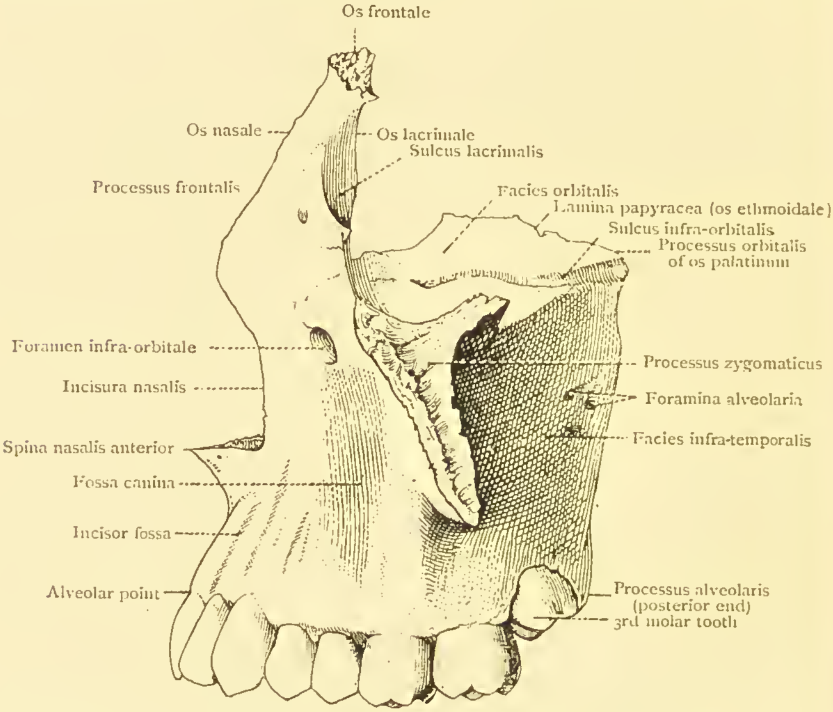

FIG. 108.—Left maxilla, outer aspect. The articulations of the bone are indicated.

palate, and is hollowed out to form the sockets, or **alveoli dentales**, for the roots of the upper teeth. This projecting mass is known as the **processus alveolaris**, and with its fellow of the opposite side it completes the *upper dental arch*. It will be noticed that when a tooth has been lost during life, the part of the alveolar process which surrounded its roots becomes absorbed. Hence in skulls of aged persons it is common to find that nearly the entire alveolar process has been absorbed. On the outer and anterior aspect of the processus alveolaris may be seen a series of ridges, the **juga alveolaria** corresponding to the underlying roots of the teeth. The ridge corresponding to the canine tooth is the most strongly marked and extends to a higher level than the others. To its inner side, and above the incisor teeth, is a slight depression known as the *incisor fossa.* To the outer side of the same ridge and extending up on to the processus zygomaticus is a large, shallow depression known as the **fossa canina.**

The portion of the maxilla which extends upwards on the inner side of the orbital opening and assists in forming the bony prominence of the nose is called the **processus frontalis.** It rises from the anterior and inner part of the corpus maxillae and reaches as high as the frontal bone with which it articulates along a serrated suture, the **sutura fronto-maxillaris.** The anterior edge of the processus frontalis joins the posterior edge of the os nasale along the almost straight **sutura naso-maxillaris,** which is directed downwards and forwards. The posterior edge lies within the orbit, and is united with the **os lacrimale.**

The outer aspect of the processus frontalis is divided into a larger anterior, and a smaller posterior portion, by a vertical ridge, which is best marked below, and is continuous with the margin of the orbital opening. This ridge, the **crista lacrimalis anterior**, forms the anterior edge of a vertical sulcus, completed by the thin and fragile os lacrimale, in which lies the saccus lacrimalis. The sulcus named the **sulcus lacrimalis** lies just within the orbit, and is continued downwards into a canal which leads from the anterior and inner part of the orbital cavity at the junction of its inner wall and floor. This canal is called the **canalis naso-lacrimalis**, or *nasal duct.* If a piece of twine be passed into it, it will be found to enter the nasal chamber, below the lowest of the curved plates of bone which may be seen on looking through the anterior opening of the nose. During life the tears which collect in the cleft between the eyelids enter the saccus lacrimalis and pass by the canalis naso-lacrimalis into the lower part of the nasal chamber.

The large anterior nasal opening, or **apertura piriformis,** which leads into the nasal chambers, is bounded *above* by the lower edges of the ossa nasalia ; on the *outside* and *below* by a curved edge of the maxilla forming the **incisura nasalis,** or *nasal notch. Below* and in the middle line, a prominent spine, the **spina nasalis anterior**, projects forwards and gives attachment to the lower end of the septum which in the living subject separates the openings of the nose. The spine is formed by portions of both maxillae uniting in the middle line ; below it, the processus alveolares of opposite sides are joined together at the **sutura inter-maxillaris.** The lowest point on this suture lies just between the median incisor teeth, and is known as the *alveolar point.*

The bridge of the nose is formed by the small nasal bones which are united together in the middle line. Each **os nasale** has four borders—an upper short and thick border, serrated to articulate with the os frontale; an anterior, or inner border, united to the os nasale of the opposite side; a posterior, or outer border, articulating with the anterior edge of the processus frontalis of the maxilla; and a thin lower border directed outwards and downwards which is joined to a part of the cartilaginous skeleton of the nose, but in the macerated skull assists in bounding the apertura piriformis. In the neighbourhood of its lower border the nasal bone is readily fractured.

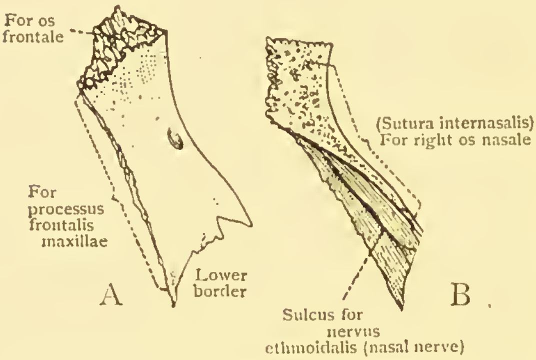

FIG. 109.—A, right, and B, left os nasale, both viewed from the right aspect.

In the side view of the entire skull, the **mandibula**, or *mandible*, occupies a position below and also behind the maxilla, and will be seen to consist of two portions—an anterior nearly horizontal **corpus mandibulae**, or *body*, and a posterior nearly vertical **ramus mandibulae**. The lower border of the corpus mandibulae meets the posterior border of the ramus at the **angulus mandibulae** which is very easily recognized in the living subject.

The posterior border of the ramus, the position of which can also be determined in life, ends above at the **capitulum mandibulae**, or *condyle*, which is surmounted by a smooth articular facet. The capitulum occupies the articular portion of the fossa mandibularis, or rests on the tuberculum articulare already described. Between the two articulating surfaces a fibro-cartilaginous pad is interposed. If the separated mandibula be examined, it will be found that the *articular surface* is convex from before backwards, and also to a less degree from side to side. It is oval in outline, its antero-posterior being much shorter than its transverse diameter, the long axis of which is directed inwards and slightly backwards.

The capitulum is supported by a short **collum mandibulae** or *neck*, which is thick from side to side, but compressed from before backwards. The inner part of the anterior aspect of the neck is hollowed out to form a shallow fossa into which most of the fibres of the musculus pterygoideus externus are inserted. The outer prominent part of the neck gives attach-

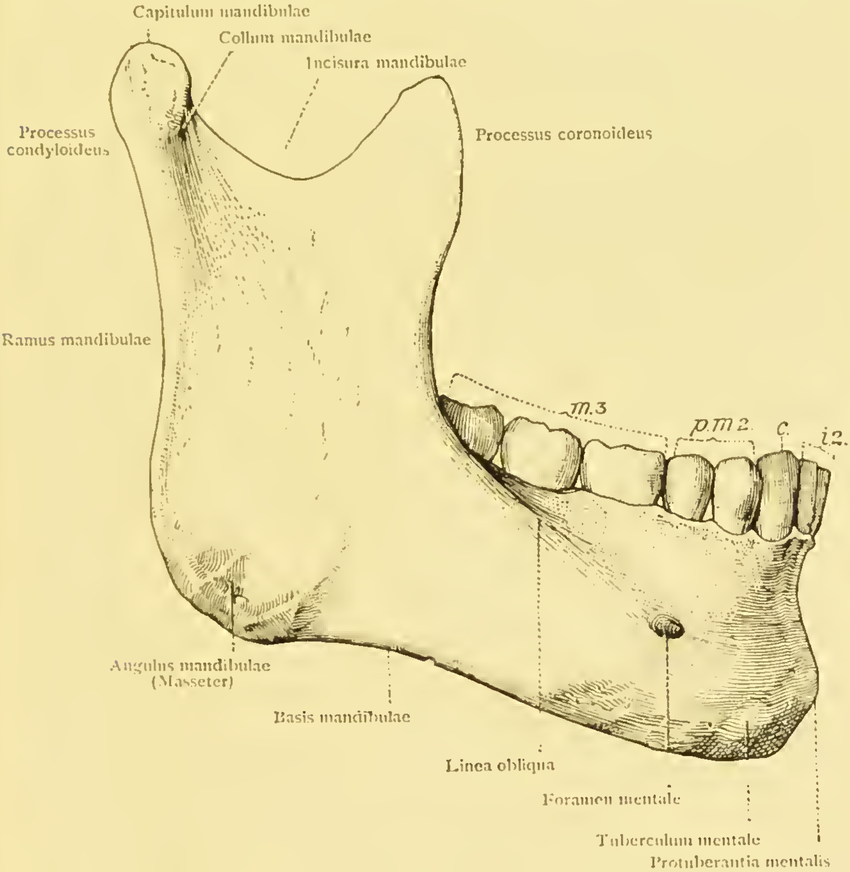

FIG. 110.—Mandibula from the right side. The incisor, canine, praemolar and molar teeth are indicated.

ment to the ligamentum temporo-mandibulare, or external lateral ligament. The term **processus condyloideus** is used to include the capitulum and collum mandibulae.

In front of the processus condyloideus the upper border of the ramus mandibulae is formed by a notch, the **incisura mandibulae**, which lies below the plane determined by the lower edge of the arcus zygomaticus. The interval between this notch and the arcus zygomaticus permits the nerves and blood-vessels of the masseter muscle to pass outwards from the region of the fossa infra-temporalis.

The thin edge of bone forming the incisura mandibulae is continued in front into the posterior border of a somewhat triangular, flattened, upward projection from the ramus mandibulae. This projection is named the **processus coronoideus**, and its apex lies well to the inner side of the arcus zygomaticus. The great temporal muscle, which descends to the inner side of the arcus zygomaticus, is attached into the borders and deep surface of this process.

The greater part of the outer aspect of the ramus mandibulae is almost flat and smooth, and gives insertion to the masseter muscle, which has its origin from the arcus zygomaticus. Near the angulus mandibulae, a series of rough marks may often be seen on the outer aspect of the mandible which give attachment to tendinous portions of the masseter.

The corpus mandibulae is composed of two symmetrical portions which are united in the middle line in front, along the *symphysis of the lower jaw.* At birth the two portions of the mandible are separate, and union takes place during the first year of life. In the adult a faint groove may be found on the posterior aspect of the symphysis indicating the line along which fusion has occurred. The lower border of the corpus mandibulae, known as the **basis mandibulae**, is thick and rounded, and can readily be felt throughout its whole extent in the living subject. The upper part contains the sockets for the roots of the teeth, and is called the **pars alveolaris.** The teeth project along its upper edge, and if they are removed, eight alveoli, which resemble moulds of the roots of the eight teeth present on each side, will be seen. These **alveoli dentales** are separated by thin plates of bone, the **septa inter-alveolaria**. If the teeth are lost during life the corresponding portion of the pars alveolaris becomes absorbed and the outline of the mandible much modified. The pars alveolaris in its anterior part exhibits a series of ridges, or **juga alveolaria**, corresponding to the underlying roots of the canine and incisor teeth.

On the smooth and rounded outer aspect of the corpus mandibulae, is the large **foramen mentale** which opens slightly backwards and upwards. It transmits the large mental nerve and the mental artery. This foramen is the termination of a canal which traverses the mandible in a direction downwards, forwards, and inwards, and begins on the deep aspect of the ramus. It should be noticed that the foramen mentale usually

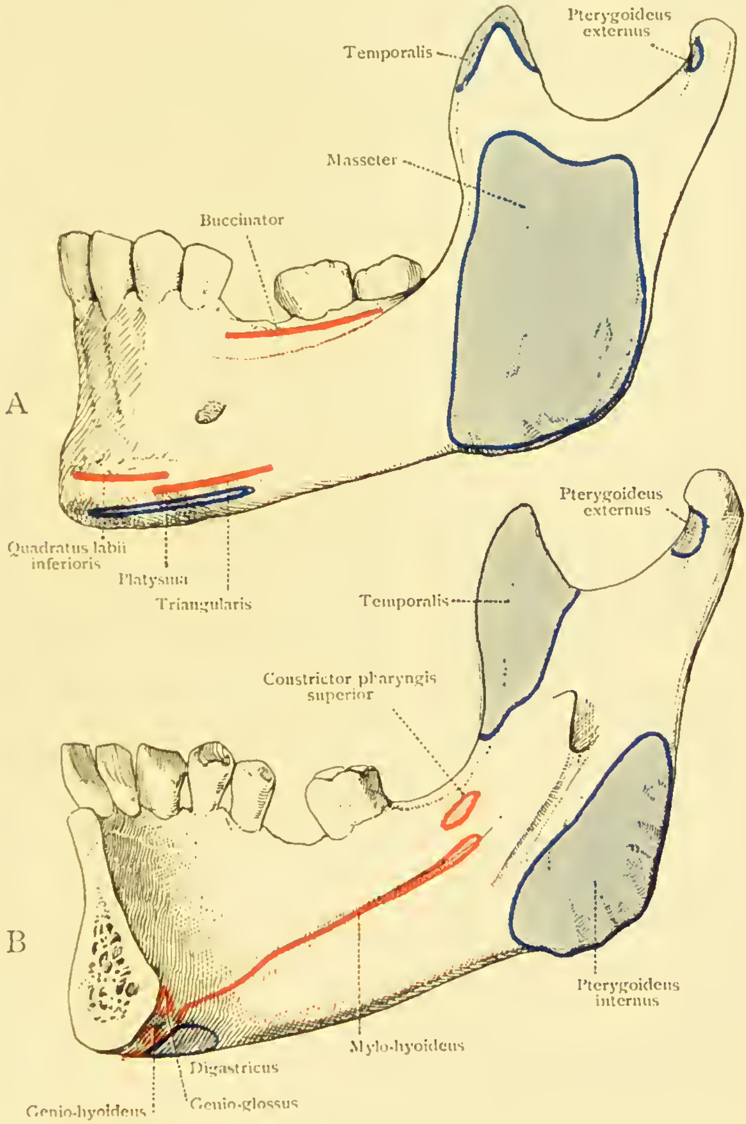

FIG. 111.—Mandibula viewed A, from the outer, and B, from the inner aspect, to show the attachment of muscles.

lies vertically beneath the second praemolar tooth and midway between the upper border and the basis mandibulae.

On the outer aspect of the corpus mandibulae may also be seen a smooth ridge, the **linea obliqua**, which is directed downwards and forwards, and begins posteriorly at the lower part of the anterior border of the ramus.

In the middle line, the lower part of the corpus mandibulae forms the prominence of the chin, known as the **protuberantia mentalis.** The projection of the bone in this region is of interest, as it is a human characteristic, and it is absent in the lower jaw-bones of the earliest known human remains. In well-marked bones, the protuberantia mentalis is continued outwards on each side, to form a small **tuberculum mentale**, which will be seen to lie a short distance from the middle line, just at the lower edge of the mandible. When the tubercles are well marked they give the protuberantia, as viewed from in front, a triangular outline; the apex of the triangle lies above, and is continued as a slight ridge, indicating the line of the symphysis, to the interval between the two central incisor teeth.

It will be found convenient to examine the deeper, or inner aspect of the mandible before undertaking an examination of the entire skull from in front.

On the inner aspect of the ramus, near its middle point, will be noticed the large **foramen mandibulare**, directed downwards and forwards. It forms the beginning of the **canalis mandibulae**, or *inferior dental canal*, and transmits the nervus alveolaris inferior, or inferior dental branch of the mandibular division of the nervus trigeminus, and the accompanying artery. The canal ends, as we have seen, at the foramen mentale on the outer aspect of the corpus mandibulae. The anterior edge of the foramen mandibulare is formed by a prominent ridge, or scale of bone, called the **lingula mandibulae**, which gives attachment to the ligamentum spheno-mandibulare, or internal lateral ligament of the lower jaw.

A narrow groove, the **sulcus mylo-hyoideus,** should be noticed beginning above, immediately behind the lingula, and directed downwards and forwards to reach the inner aspect of the corpus mandibulae. It indicates the course of the nervus mylo-hyoideus and its companion artery. The nerve is a branch of the nervus alveolaris inferior, and takes its origin just as the latter is about to enter the canalis mandibulae. The artery has a similar origin from the arteria alveolaris inferior.

The area of bone near the angulus, below and behind the foramen mandibulare and sulcus mylo-hyoideus, is rough for the attachment of the pterygoideus internus muscle.

The inner aspect of the corpus mandibulae is divided into upper and lower portions by an obliquely running ridge, which begins behind the last molar tooth, and runs downwards and forwards towards the lower end of the symphysis. This ridge, known as the **linea mylo-hyoidea**, indicates the attachment of the mylo-hyoideus muscle. The smooth, slightly hollowed area which lies below and behind this line, forms the **fovea sub-maxillaris**, and lodges a small part of the sub-maxillary gland; while the shallow fossa, **fovea sub-lingualis**, which

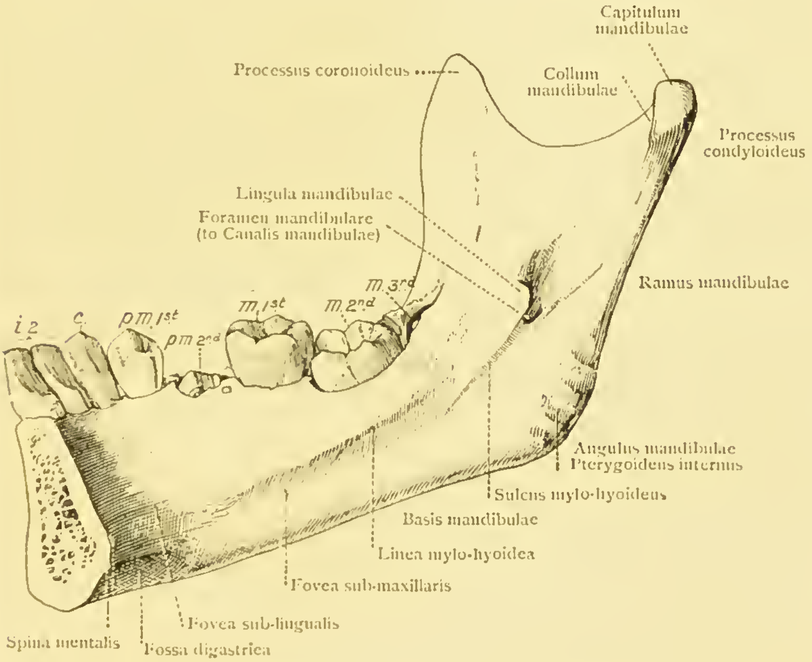

FIG. 112.—Deep aspect of right half of mandibula. From a subject aged eleven years. The incisor, canine, praemolar, and molar teeth are indicated.

lies above it, and near the symphysis, is related to the sub-lingual gland. One, or sometimes two pair of minute tubercles, often fused together, and forming a prominence, known as the **spina mentalis**, are present near the lower end of the symphysis, and give origin, on each side, to the genio-hyoideus and the genio-glossus muscles. On each side of the middle line, and just behind the lower border of the bone, is an oval impression, the **fossa digastrica**, which marks the attachment of the anterior belly of the musculus digastricus.

THE SKULL FROM IN FRONT.

Looking at the skull from in front—*norma frontalis*—we recognize at once the upper cranial portion, formed in this part by the os frontale, and the lower facial portion largely occupied by the great openings of the orbital and nasal cavities. The alveolar arches of the maxillae and mandible, with their embedded teeth, bounding the wide opening of the mouth eavity, are also conspicuous objects.

The anterior aspect of the cranium forming the forehead is composed entirely of the **os frontale**, which is usually a single bone in the adult, although at birth, and in some individuals throughout life, it is made up of two separate portions. Nearly always some trace of the **sutura frontalis** (fig. 114), which divides these two portions of the os frontale, can be reeognized passing upwards from the *nasion*, or middle point, of the sutura naso-frontalis. In young subjects there is a prominence on the curve of the os frontale on each side of the middle line, about midway between the arch over the orbit and the eoronal suture. The prominence is known as the **tuber frontale**, or *frontal eminence*, and is particularly noticeable in the skulls of infants (fig. 172). In the middle line above the depression at the nasion, there will be seen the bulging of the **glabella.** Passing outwards and a little upwards from it, on each side, is a very variably developed elevation, known as the **arcus superciliaris**, or *superciliary ridge.* This lies above the inner part of the arch which bounds the opening of the orbita. The glabella and the arcus supereiliaris are more pronounced in the skulls of men than in those of women. The slight depression above the glabella is known as the *ophryon.*

The arch, which forms the upper edge of the orbital opening, or **margo supra-orbitalis**, is formed entirely by the os frontale, and can be readily felt in the living subject. Its outer pillar joins the os zygomaticum, and is known as the **processus zygomaticus**, or *external angular process* of the os frontale. This process forms an important landmark in the living subjeet, and its posterior border is continued upwards and then backwards into the linea temporalis. The inner pillar, or *internal angular process* of the margo supra-orbitalis, joins the upper end of the os lacrimale. It is separated from the corresponding pillar of the opposite side by an interval, which is occupied by the upper ends of the ossa nasalia and the processus frontales of the maxillae. It will be noticed that the margo supra-orbitalis is more sharply defined in its outer two-thirds, and that it is more rounded in its inner third. Usually about the junction of its inner and middle thirds a notch, the **incisura supra-orbitalis,** will be seen. This transmits the supra-orbital nerve, and also an artery which accompanies it; sometimes it is converted into a bony foramen, the **foramen supra-orbitale.** In many cases, both a notch and a foramen

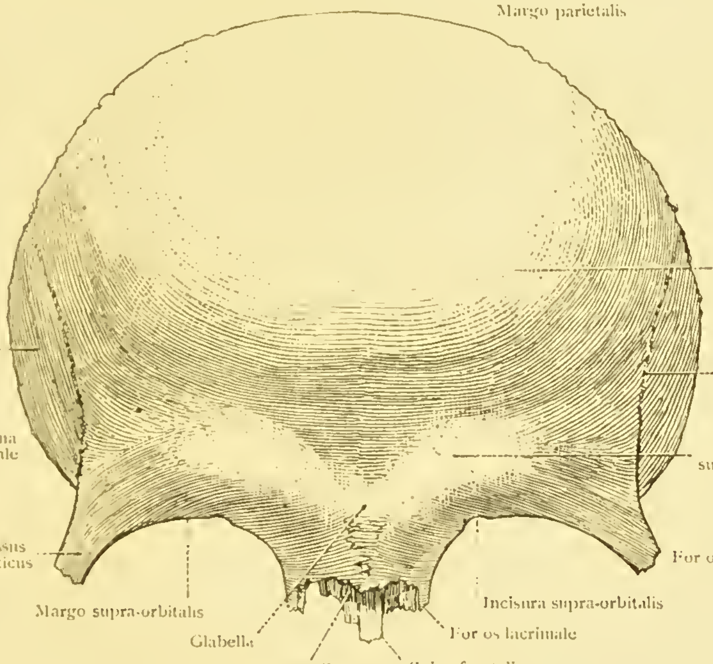

FIG. 113.—Os frontale from in front.

are present. The position of the notch, in the living subject, can usually be found by pressing the finger upwards and backwards against the margo supra-orbitalis. Nearer to the middle line than the incisura supra-orbitalis a second, more minute, notch is often present. This affords passage to the nervus frontalis, or supra-trochlear nerve, and its companion artery; it is known as the **incisura frontalis.**

The large opening of the orbit, the **aditus orbitae,** next demands our attention. It is bounded, above, by the margo supra-orbitalis of the os frontale; externally and below, by the orbital margin of the os zygomaticum; inferiorly, by the margo infra-orbitalis of the maxilla; and internally, by the processus frontalis of the maxilla. The opening is quadrilateral in outline, with rounded angles. The greatest diameter of the orbital opening passes outwards and slightly downwards.

The space which intervenes between the openings of the orbits, will be seen to be occupied by the processus nasales of the maxillae and by the ossa nasalia, which together form the bony portion of the projection of the nose.

It will be noticed that the greatest transverse diameter of the facial portion of the skull lies below the plane of the orbits, and corresponds to a line passing from the right to the left arcus zygomaticus.

The **foramen infra-orbitale** opens on the corpus maxillae about half an inch below the margo infra-orbitalis, and is directed downwards and inwards. It lies slightly to the outer side of a vertical line passing through the incisura supra-orbitalis, and usually in the same vertical plane as the **foramen mentale** of the mandible.

The large anterior opening of the nose, or **apertura piriformis**, is somewhat pear-shaped, its greatest transverse diameter lying in its lower part. It lies at a lower level than the orbital cavities, and between them. As we have already seen, it is bounded in the middle line below by the spina nasalis anterior; on each side by the curved inner edge, or incisura nasalis of the corpus maxilla, and superiorly by the thin lower edges of the ossa nasalia. On looking into the opening the thin bony septum, **septum nasi osseum**, which divides the right and left nasal chambers will be seen. The lower part of the septum, which reaches to the spina nasalis inferior, is formed by the **vomer**; the upper part, which comes forward to the posterior aspect of the ossa nasalia, is a portion of the **os ethmoidale.**

Two thin, curved, bony plates may be seen, projecting into each nasal chamber from its outer wall, and almost reaching to the septum. The lower of these is the **concha nasalis inferior**, or *inferior turbinated bone*; the upper is the **concha nasalis media**, or *middle turbinated bone.* The former is a separate bone, the latter is merely a processus of the os ethmoidale. The portion of the nasal chamber, which lies under shelter of, and below the concha nasalis inferior is known as the **meatus nasi inferior**; into it, as we have already seen, the canalis naso-lacrimalis opens. The recess, below the concha nasalis media, is called the **meatus nasi medius**, and into it opens the sinus maxillae, and also some other air-containing cavities which lie in the os ethmoidale.

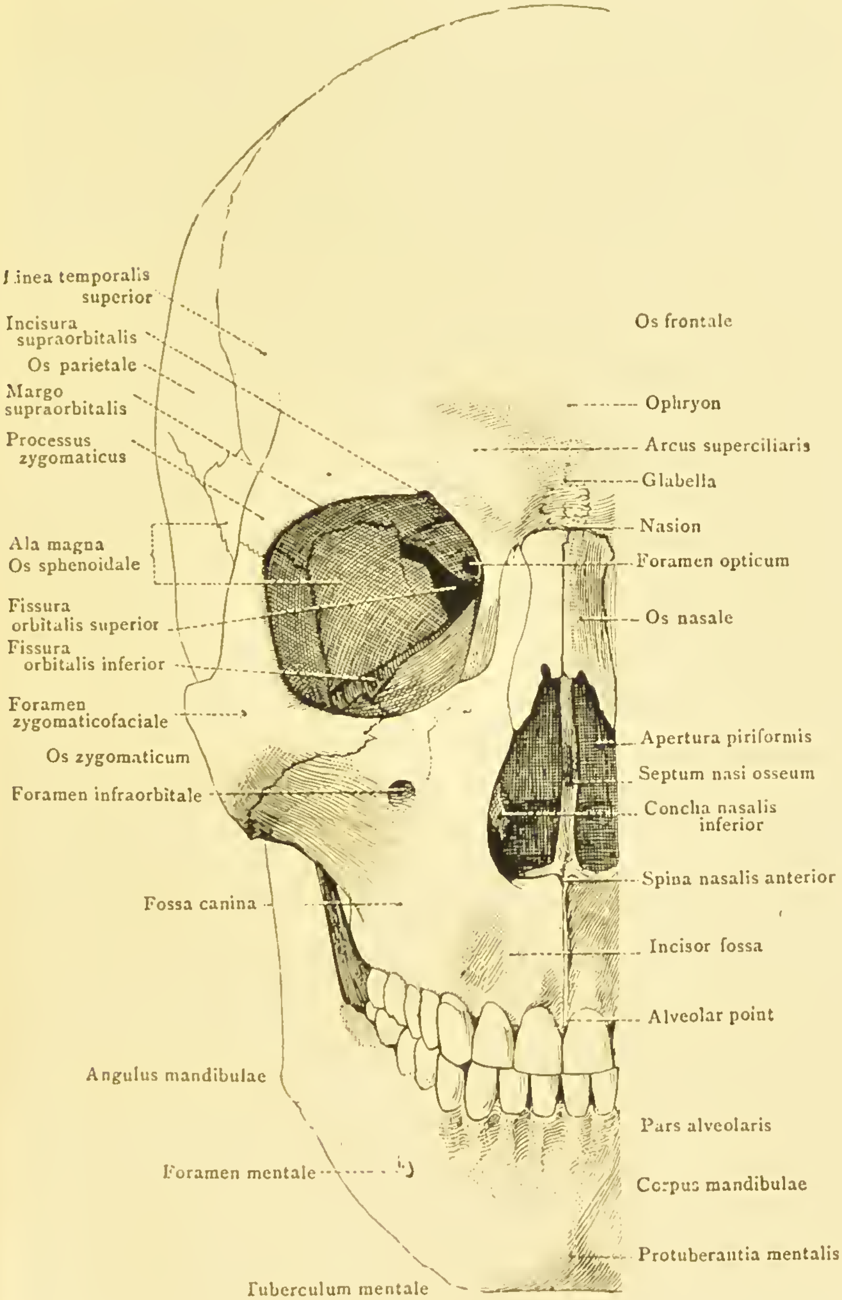

FIG. 114.—Skull from in front.

Below the opening of the nose the alveolar processes of the maxillae unite in the middle line, and from them the upper teeth project downwards. The small shallow *incisor fossa*, immediately above the incisor teeth, and the large **fossa canina**, placed to its outer side and extending upwards on to the root of the processus zygomaticus of the maxillae, should be identified. As has already been mentioned, these fossae are separated by the ridge caused by the root of the canine tooth.

THE ORBITAL CAVITY.

The orbital cavities should now be carefully studied, their boundaries examined, and the various openings by which they communicate with other regions of the skull identified.

Each **orbita** is a pyramidal cavity, with its apex directed backwards and slightly inwards, and its base forwards and slightly outwards. The cavities are so disposed that the inner wall of the left is parallel to the inner wall of the right orbit, and the outer walls, if produced backwards, would at their meeting form approximately a right angle. In each orbit we recognize a roof, outer wall, floor, and inner wall.

The *roof*, mainly formed by the **facies orbitalis** of the os frontale, is smooth and concave from side to side. This surface forms the under aspect of the thin **pars orbitalis**, or *orbital plate*, of the os frontale, which intervenes between the anterior part of the cranial cavity and the orbit, and is continuous in front with the margo supra-orbitalis. In its outer and anterior part, the roof is hollowed to form the **fossa glandulae lacrimalis**, which lodges a considerable portion of the lacrimal gland. On the anterior and inner part of the roof may usually be seen a minute depression, or sometimes a little spine, the **fovea trochlearis**, or the **spina trochlearis**, which is related to the pulley of the superior oblique muscle. The extreme posterior part of the orbital roof is formed by the **ala parva** of the **os sphenoidale**. At the apex of the orbit, this bone is pierced by the large **foramen opticum**, through which the nervus opticus leaves, and the ophthalmic artery enters the orbit.

The *outer wall* of the orbit is formed by the **facies orbitalis** of the **ala magna** of the os sphenoidale, and by the **facies orbitalis** of the **os zygomaticum**. A wide cleft, the **fissura orbitalis superior**, or *sphenoidal fissure*, lies between the ala parva and ala magna of the os sphenoidale as they lie respectively in the roof and lateral wall of the orbit. This cleft leads into the middle fossa of the cranial cavity, and its inner end, which is wider than its outer extremity, lies below and external to the foramen opticum. Through the fissura orbitalis superior, the ophthalmicus division of the nervus trigeminus and the nerves for the eye-muscles, viz. nervus oculo-motorius, trochlearis, and abducens, enter the orbit. The ophthalmic veins pass backwards through the same fissure to enter the sinus cavernosus, within the cranial

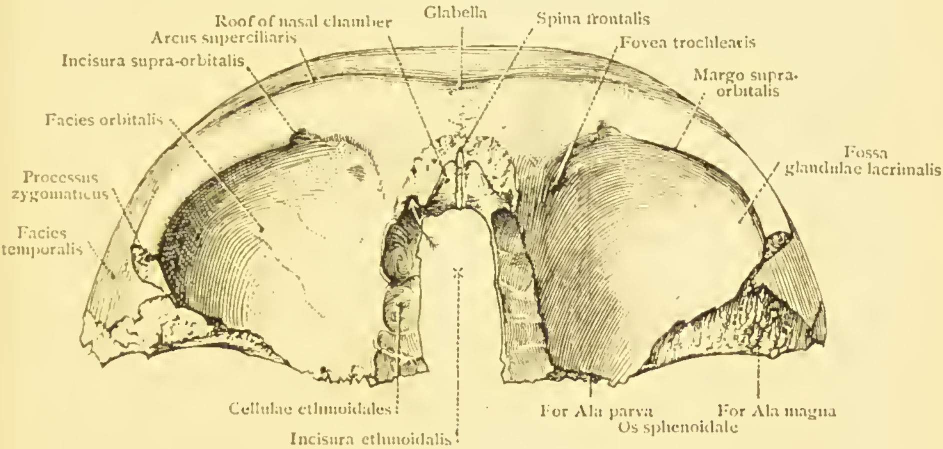

FIG. 115.—Os frontale from below; showing roof of orbital cavity.

cavity. On the facies orbitalis of the os zygomaticum is the minute **foramen zygomatico-orbitale**, which forms the common opening of the canals traversing the os zygomaticum, already described (page 188).

The *floor* of the orbit slopes downwards and outwards, and is formed by the **facies orbitalis** of the **maxilla**, and to a less extent, by a part of the **facies orbitalis** of the **os zygomaticum.** Far back in the orbit a very minute portion of the **os palatinum** may be identified on the floor of the cavity. A well-marked cleft, the **fissura orbitalis inferior**, or *spheno-maxillary fissure*, separates the ala magna of the os sphenoidale from the maxilla, and lies between the outer wall and floor of the orbit. This fissure is usually wider near its anterior and outer end than at its posterior and inner end, where it comes close to the inner end of the fissura orbitalis superior. It leads from the orbit into the fossa infra-temporalis and fossa pterygo-palatina. Far back on the orbital floor is a well-marked groove, the **sulcus infra-orbitalis**, which, as it is traced forwards, becomes a tunnel for the transmission of the nervus infra-orbitalis and its accompanying artery. This tunnel is the **canalis infra-orbitalis**, and ends, as we have seen, at the foramen infra-orbitale. The sulcus, and the canalis infra-orbitalis, are both formed by the maxilla (see fig. 108).

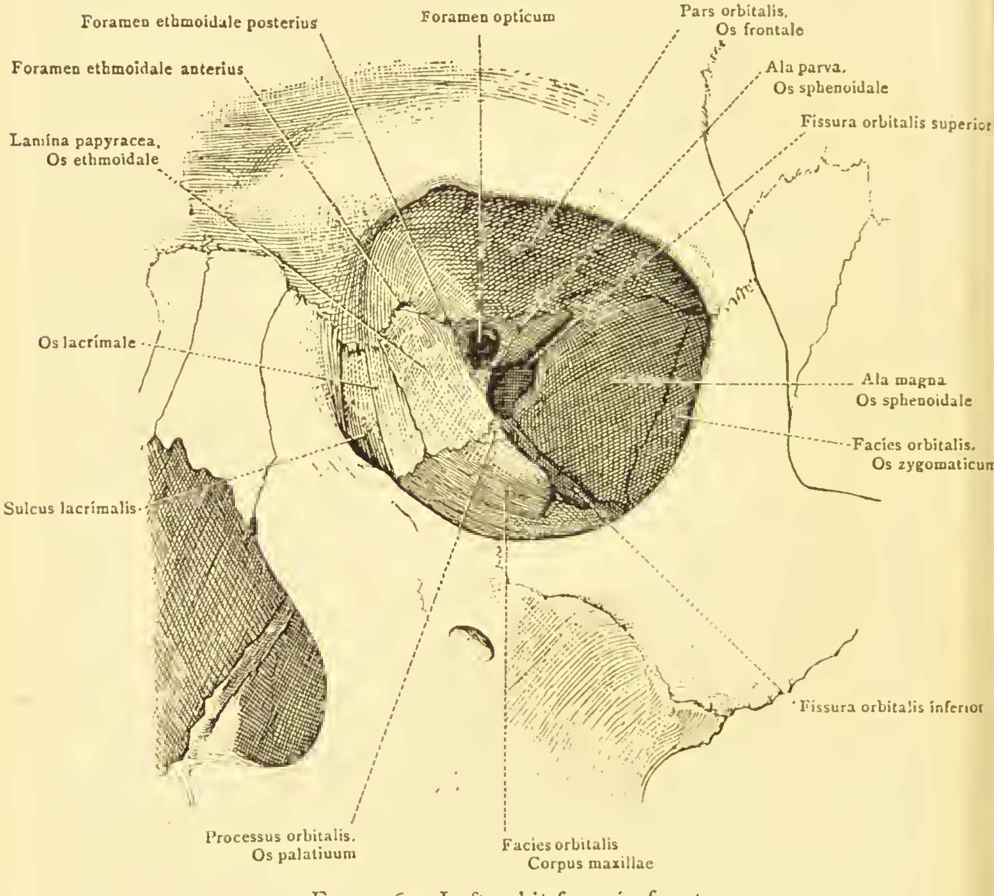

Fig. 116.—Left orbit from in front.

The *inner wall* of the orbit is composed of a very delicate bony layer, which separates the orbital cavity from the air-cells of the os ethmoidale, and from the nasal chamber. Great care should be used in examining this wall, as the bone is very fragile and readily broken; on no account should the finger, or any instrument, be pressed against it.

The largest share in the formation of the inner wall is taken by the thin quadrilateral **lamina papyracea**, or *os planum*, of the os ethmoidale. This plate is so thin that it is semi-transparent. It is united along its lower horizontal edge by a suture with the facies orbitalis of the maxilla. By its anterior vertical border it joins the os lacrimale, and by its posterior vertical edge it is united to the os sphenoidale. At its upper horizontal border, the lamina papyracea joins the facies orbitalis of the os frontale, along a suture which is interrupted by two minute apertures, known as the **foramen ethmoidale anterius** and **posterius**, or the *anterior* and *posterior internal orbital canals.* These transmit the minute anterior and posterior ethmoidal branches of the ophthalmic artery, and the anterior foramen also transmits the main continuation of the nervus naso-ciliaris, or nasal branch, from the ophthalmicus division of the trigeminus. The further course of this nerve in relation to the bones of the skull is described on page 226. Usually the postero-inferior angle of the lamina papyracea may be seen to join the minute facies orbitalis of the os palatinum.

FIG. 117.—Left os lacrimale, orbital aspect.

In front of the lamina papyracea the inner orbital wall is formed by the **os lacrimale**, an extremely thin bony plate which reaches upwards as high as the os frontale, downwards to the facies orbitalis of the maxilla, and forwards to the posterior border of the processus frontalis of the maxilla. The posterior part of the orbital surface of the os lacrimale lies in the same plane as the os papyracea, but the anterior part is grooved vertically, and completes, with the adjacent groove on the processus frontalis maxillae, a sulcus for the saccus lacrimalis and the upper end of the ductus naso-lacrimalis. This **sulcus lacrimalis** is bounded by an **anterior** and a **posterior crista lacrimalis**; the former lying on the processus frontalis maxillae, the latter on the os lacrimale. The crista lacrimalis posterior, at its lower end, comes forwards, and, bridging across the sulcus, converts it into a foramen which is the beginning of the **canalis naso-lacrimalis**, leading into the lower meatus of the nose. The little spur which turns forwards from the lower end of the crista lacrimalis posterior is known as the **hamulus lacrimalis**. It should be noticed that the inner part of the lower margin of the orbital opening is continued into the crista lacrimalis anterior, and that the inner part of the upper margin is continued into the crista lacrimalis posterior. Hence the sulcus lacrimalis lies just at the junction of the inner wall of the orbit and the facial aspect of the processus frontalis maxillae.

Before completing the survey of the orbital cavity, the student should recognize that it is intimately related to several important fossae and cavities of the skull. *Above*, lies the anterior cranial fossa; *behind and to the outer side*, the middle cranial fossa, the temporal fossa, and the pterygo-palatine fossa; *to the inner side*, the ethmoidal air-cells and the nasal chamber, and *below*, the cavity of the antrum, or sinus maxillaris. The frontal air sinus is usually related to a variable amount of the roof and to the anterior and upper part of the inner wall; and the sphenoidal air sinus often comes into relationship with the orbit near the apex of the cavity.

THE UNDER ASPECT OF THE SKULL.

When the skull is viewed from below—*norma basilaris*—the under surface of the cranium is seen to be very irregular, and exhibits many projections and depressions. A large number of foramina, some of considerable size, are also present, through which important structures pass as they enter and leave the cranial cavity.

The under aspect of the facial part of the skull is formed mainly by the maxillae with their conspicuous processus alveolares supporting the teeth and forming an arch which encloses the hard palate between its limbs. The great openings—choanae—which lead into the nasal chambers lie side by side immediately above the free posterior edge of the hard palate and are conspicuous landmarks.

We shall begin our examination at the posterior, or occipital region of the under aspect of the skull.

The **foramen occipitale magnum**, by far the largest of the foramina leading from the cranial cavity, lies, as we have seen, in the entire skeleton immediately above the upper end of the canalis vertebralis. Through this great foramen the spinal cord and the lower part of the brain, or medulla oblongata, become continuous, and also through it the vertebral arteries enter the cranial cavity. The membranes which surround the brain and spinal cord are continuous, as they pass through the foramen, and enclose a number of smaller structures, including the right and left spinal accessory nerves, and the minute spinal arteries which lie in contact with the spinal cord as they enter, or leave the cranium. The foramen, which is oval in outline, is a little narrower in front than

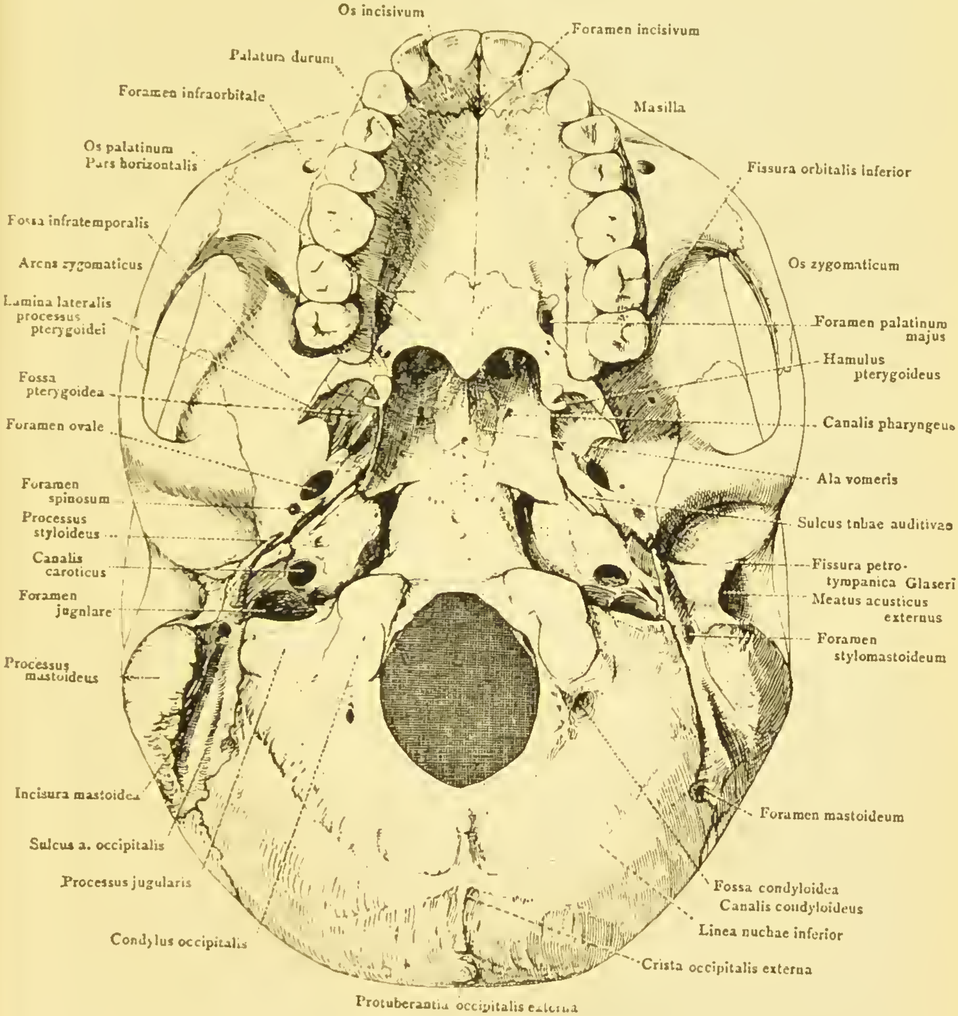

FIG. 118.—Skull from the under aspect.

behind, and measures nearly one and a half inches in its antero-posterior, or longest, diameter. The opening looks directly downwards.

On each side of the anterior part of the foramen magnum lies a **condylus occipitalis**, or *occipital condyle*, by means of which the cranium articulates with the atlas vertebra. The condyles lie nearer together in front than behind, and are convex in their long axes, which are directed forwards and inwards. The inner edge of each condylus occipitalis lies on a lower plane than the outer edge; and just above the inner edge there is a rough area for the attaehment of the alar, or check ligament, which comes, as we have already seen, from the upper part of the odontoid process of the axis vertebra, and limits the amount of lateral rotation of the head.

By tilting the skull, it becomes possible to recognize the presenee of a canal, the **canalis hypoglossi**, or *anterior condylar foramen*, which, piercing the attachment of the condylus occipitalis to the under aspect of the skull, is directed forwards and outwards from the region of the foramen magnum. This canal transmits the twelfth cranial nerve, or nervus hypoglossus, which is the great motor nerve of the tongue. The canal ends immediately to the outer side of the anterior part of the condylus occipitalis.

The foramen magnum is surrounded by the parts of the **os occipitale**—behind, lies the **squama occipitalis**; on each side, the **pars lateralis**; and in front, the **pars basilaris**. These parts are separate at birth (see fig. 174), being merely united by cartilage, but in the child they become united to form the single bone, the os occipitale.

The **squama occipitalis**, often spoken of as the *tabular part* of the os occipitale, forms the floor of the posterior part of the cranial cavity, and also its posterior wall. As viewed from below, its surface is uneven, and marked by a series of impressions for the attachment of muscles which reach it from the neck.

In most cases a median ridge may be recognized, extending from the foramen magnum backwards and upwards to the **protuberantia occipitalis externa**. This ridge, the **crista occipitalis externa**, gives attachment to fibres of the ligamentum nuchae, which forms a septum between the muscles of opposite sides. The protuberantia occipitalis externa varies much in different skulls, but when well developed, it has a somewhat triangular outline, the apex of which is directed downwards, and affords attachment to the superficial part of the ligamentum nuchae.

Passing outwards on each side from the protuberantia is a rough arching ridge, the **linea nuchae superior**, or *superior curved line*; in well-marked specimens this may be traced over the lateral angle of the squama oecipitalis on to the outer part of the processus mastoideus of the os temporale. The linea nuchae superior is usually easily identified because it separates the smooth upper part of the squama occipitalis, covered during life by the scalp only, from the rough lower part which gives attachment to the muscles of the neck. The surface of bone above the ridge is spoken of as the **planum occipitale,** and that below as the **planum nuchale.** Near its inner end, the linea nuchae superior gives origin to a part of the trapezius, and near its outer end insertion to a part of the sterno-cleido-mastoideus.

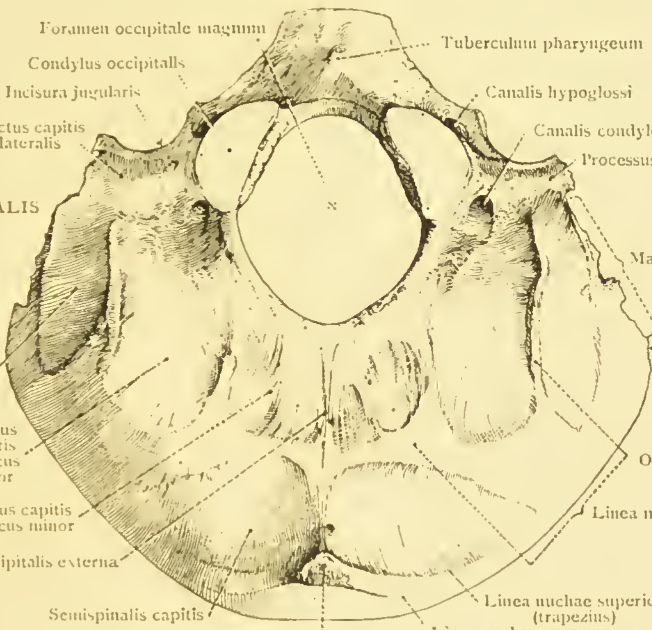

FIG. 119.—Os occipitale from below.

Immediately above the linea nuchae superior, a shorter, more arched, and less clearly defined line may usually be recognized. This, the **linea nuchae suprema**, or *highest curved line*, marks the origin of the musculus occipitalis, or posterior belly of the occipito-frontalis, one of the muscles of the scalp.

About half-way between the foramen magnum and the linea nuchae superior the student should look for the **linea nuchae inferior**, or *inferior curved line*, which arches outwards and forwards from the middle point of the crista occipitalis externa. Unlike the linea superior, the linea inferior does not extend beyond the margin of the os occipitale. It assists in marking off the areas of attachment for a number of important muscles on the planum nuchale. These areas are easily recognized in well-marked bones, but in other cases are difficult to determine. Between the linea superior and inferior, the musculus semispinalis capitis, or complexus, is attached near to the mesial plane, and more laterally the obliquus capitis superior. Below the linea inferior, between it and the margin of the foramen magnum, the planum nuchale gives insertion to the rectus capitis posticus major and minor muscles, the insertion of the latter being nearer to the mesial plane (see fig. 119).

The **pars lateralis** of the os occipitale forms the cranial wall immediately to the outside of the foramen magnum, and on it is situated the condylus occipitalis, which we have already studied.

Behind the condyle is a depression, the **fossa condyloidea**, the floor of which is extremely thin, and sometimes pierced for the transmission of a vein by a foramen, named the **canalis condyloideus**, or the *posterior condylar foramen.*

To the outside of the condylus lies a rough area for the insertion of the rectus capitis lateralis muscle. This area is formed by the under aspect of the **processus jugularis**, the part of the occipital bone which lies immediately above the transverse process of the atlas vertebra. The processus jugularis is united at its outer end to the pars petrosa of the os temporale by a plate of cartilage, forming the synchondrosis petro-occipitalis, which becomes ossified only when adult age is reached. Posteriorly the processus jugularis is continuous with the remaining part of the pars lateralis of the os occipitale, but anteriorly it has a free smooth notched border, which is known as the **incisura jugularis**, and forms the posterior boundary of the **foramen jugulare.**

The position and form of the **foramen jugulare** should be carefully studied. It lies between the os occipitale and the pars petrosa of the os temporale. Behind, is the processus jugularis, and to the inner side, the anterior end of the canalis hypoglossi. In front, the student will recognize the lower end of the great **canalis caroticus**, and to the outer side, the slender projecting **processus styloideus** and the small **foramen stylo-mastoideum.** The foramen jugulare is wide posteriorly, and narrower towards its anterior part. Its long axis is directed forwards and inwards. Through the wide posterior and outer portion of the foramen the great sinus transversus, or lateral blood sinus, passes out of the cranium to become the vena jugularis interna; more internally, through a narrower portion, the glosso-pharyngeus, vagus, and accessorius (spinal accessory) nerves issue from the cranial cavity; and through the very narrow anterior and inner end of the foramen, the sinus petrosus inferior passes out on its way to join the vena jugularis interna. In some cases the foramen is more or less completely subdivided into three compartments for the structures mentioned.

The **pars basilaris**, of the os occipitale, lies in front of the foramen magnum. It is rough from side to side, and, in the adult skull, is so joined to the corpus of the os sphenoidale that the line of union is no longer visible; until about the twentieth year the two bones are united by a synchondrosis. The pars basilaris is about one inch in length, and narrower at its anterior than at its posterior end. Just in front of the middle point of its under surface, there is a minute rounded tubercle, the **tuberculum pharyngeum**, or *pharyngeal tubercle*, for attachment of the median raphe formed by the superior constrictor muscles of the pharynx.

To the outside of the anterior portion of the pars basilaris and of the corpus of the os sphenoidale, there is an irregularly-shaped opening, bounded anteriorly by the os sphenoidale and externally by the inner end of the pars petrosa of the os temporale. This foramen is known as the **foramen lacerum**, and during life it is closed by a mass of cartilage, which may be regarded as an unossified portion of the cranial wall.

Having completed the study of the markings on the cranial wall where it is formed by the os occipitale, the student should again direct his attention to the under aspect of the processus jugularis, and note the manner in which its outer end is joined to the pars petrosa of the os temporale, at the **synchondrosis petro-occipitalis**. The little cartilaginous plate which intervenes, in this position, between the two bones is to be regarded as a persisting portion of the primitive cartilaginous base of the skull. Running backwards, upwards, and slightly outwards from the tip of the processus jugularis, we have the **sutura occipito-mastoidea**, which ends at the *asterion*, the point where the sutura lambdoidea and the sutura parieto-mastoidea also terminate.

Lying immediately to the outer side of the processus jugularis, on the **pars mastoidea** of the **os temporale**, is a narrow groove, the **sulcus arteriae occipitalis**, for the occipital artery.

To the outside of this sulcus lies the **processus mastoideus**, on the inner aspect of which there is usually a deep groove, called the **incisura mastoidea**, or *digastric fossa*, for the origin of the posterior belly of the digastricus. The outer aspect of the processus mastoideus is, as we have seen, rounded and convex, and gives attachment to a number of important muscles, which reach it from the neck. The process itself is usually composed of loose cancellous tissue with an outer shell of compact bone. The contained spaces are filled sometimes with marrow, sometimes with air, and in the latter case communicate with the cavum tympani through the **antrum tympanicum**, or *mastoid antrum* already mentioned (see page 185, also page 297).

A narrow interval separates the base of the processus mastoideus from the root of the processus styloideus. The latter lies on an anterior and inner plane to the former, and between the two a small foramen should be noticed. This is the **foramen stylo-mastoideum**, and transmits the great motor nerve of the face—the nervus facialis, or seventh cranial nerve. The foramen is the end of a long bony tunnel, which runs a complicated course within the pars petrosa of the os temporale, and is known as the **canalis facialis**, or 'aqueduct of Fallopius' (see page 236). A very minute artery (stylo-mastoid) enters the foramen, and runs with the nerve.

The slender **processus styloideus** is directed downwards, inwards, and forwards, and tapers gradually towards its distal end. As we have seen, it is sometimes united to the skull by ligamentous tissue only, and it varies very much in length. Often a thickening, or irregularity, in its middle part indicates the region where fusion of two portions, originally separate, has taken place. We have already noticed that the process gives origin to a number of slender muscles, and that its apex gives attachment to the stylo-hyoid ligament, which passes to the os hyoideum (see also page 262).

In front and to the outer side of the processus styloideus, an edge of bone projects downwards from the pars tympanica of the os temporale, and partly ensheathes the base of the processus styloideus. This is known as the **vagina processus styloidei**, or *vaginal process* of the tympanic plate.

In front of the vagina processus styloidei lies the great **fossa mandibularis**, with its posterior, nearly vertical wall formed by the thin plate of the pars tympanica, which alone separates it from the meatus acusticus externus. We have already noticed that the fossa may be divided into an anterior portion, the wall of which is articular, and a posterior portion, which lodges a part of the parotid gland.

When we view the fossa from below, a well-marked fissure —the **fissura petro-tympanica**,[1] or *fissure of Glaser*—is seen to separate these two portions.

The slender chorda tympani branch of the nervus facialis emerges, and the tympanic vessels enter the tympanic cavity

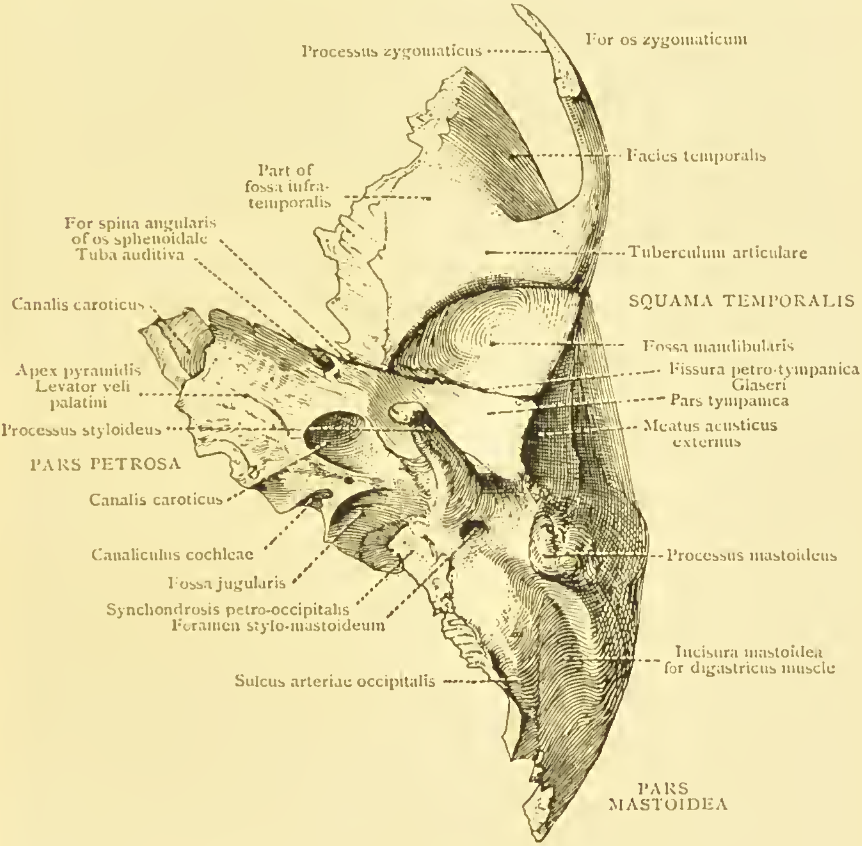

FIG. 120.—Left os temporale from below.

through the narrow cleft towards the inner end of this fissure. A slender ligamentous structure, known as the ligamentum mallei anterius, also passes through the fissure and is con-

[1] At the outer end of the fissura petro-tympanica, the tympanic plate joins the squama temporalis, but, as the fissure is traced inwards, a slender portion of the pars petrosa will be seen to intervene between the pars tympanica and the squama temporalis, and hence it happens that the fissure is named petro-tympanica, and not squamo-tympanica (fig. 120).

nected with the malleus, one of the ear ossicles which lie within the cavum tympani. The form of the anterior articular portion of the fossa and its relationship to the tuberculum articulare should be carefully studied.

It will be noticed that the long axis of the articular part of the fossa mandibularis lies transversely, and that the fossa is bounded in front by a smooth convex articular elevation, the long axis of which passes nearly horizontally inwards. We have already seen that this elevation, the **tuberculum articulare,** or *eminentia articularis*, lies on the under aspect of the root of attachment for the processus zygomaticus of the os temporale. Towards its inner end it ceases to be articular, and it fades away, near the inner end of the fissura petro-tympanica, in the region of the **spina angularis** of the os sphenoidale.

When the mouth is opened widely, or when the lower jaw is drawn well forwards, the capitulum mandibulae, covered by the interarticular cartilage, leaves the fossa mandibulae and slips forward on to the tuberculum articulare. This forward movement of the capitulum can be appreciated by the student if he press the tip of his finger immediately behind the collum mandibulae and just in front of his ear-hole, and then open his mouth widely.

The well-defined lower opening of the **canalis caroticus** on the **pars petrosa** of the **os temporale**, next claims our attention. This aperture is approximately circular in outline, and the canal into which it leads is directed at first upwards and then forwards and inwards, to open into the foramen lacerum at the anterior end of the pars petrosa, or **apex pyramidis**. The canalis caroticus lies entirely in the pars petrosa and transmits the arteria carotis interna and a network of sympathetic nerve fibres. The lower opening of the canal is immediately in front of the foramen jugulare, and just behind the spina angularis of the os sphenoidale.

The rough area, on the pars petrosa, which lies in front and to the inner side of the aperture of the canalis caroticus gives origin to the musculus levator veli palatini.

In addition to the well-marked and important openings already described, a careful study of this region of the skull will reveal a number of minute and less important openings.

(1) One of these lies on the ridge of bone which separates the carotid canal from the foramen jugulare. It is just large enough to admit the point of a pin, and forms the beginning of the **canaliculus tympanicus**, which leads upwards into the cavum tympani. Through it passes the nervus tympanicus, a minute branch of the glosso-pharyngeus, or ninth

cranial nerve, which, as we have seen, leaves the cranium through the middle compartment of the foramen jugulare. The little depression, in which the canaliculus tympanicus begins, lodges a ganglionic swelling on the nervus glosso-pharyngeus.

(2) Another minute canal leads upwards from the outer wall of the foramen jugulare, and transmits a slender branch of the vagus, or tenth cranial nerve. The little nerve is called the auricular branch of the vagus and finally comes to the surface behind the meatus acusticus externus in the fissura tympano-mastoidea, which separates the pars tympanica from the pars mastoidea of the os temporale.

(3) In the lower part of the canalis caroticus a small opening is present for a tympanic branch from the sympathetic plexus which accompanies the arteria carotis interna.

(4) On the outer wall of the anterior part of the foramen jugulare, a small pyramidal depression will be seen on the pars petrosa of the os temporale. In the bottom of this depression there is the minute opening of a little canal known as the **canaliculus cochleae.** It leads into the cochlear portion of the bony cavity, in which lies the organ of hearing. Sometimes the opening of this canaliculus lies too high up to be easily recognized in the entire skull.

The student should now clearly define the district of the under aspect of the skull which is formed by the **os temporale,** and recognize the lines along which the bone articulates with the os occipitale and the ala magna of the os sphenoidale.

The **sutura occipito-mastoidea** which extends as far forwards as the processus jugularis, and separates the **pars mastoidea** from the os occipitale, has already been noticed. From the foramen jugulare forwards the os occipitale is separated from the **pars petrosa** of the os temporale by the **fissura petro-occipitalis** and the **foramen lacerum.** Anteriorly, the posterior part of the ala magna of the os sphenoidale is wedged backwards, into the angular interval between the **squama temporalis** and the **pars petrosa** of the os temporale. It will be recognized that the apex of the wedge, formed by the ala magna, lies at the inner end of the fossa mandibulae and of the fissura petro-tympanica, and is formed by the **spina angularis.** It should be noticed that in front of the fossa mandibulae, a small portion of the squama temporalis, which lies to the outside of the ala magna of the os sphenoidale, assists in forming the fossa infra-temporalis.

Along the line where the ala magna of the os sphenoidale joins the pars petrosa of the os temporale, a shallow groove may usually be recognized. This is the **sulcus tubae auditivae,** and is an important landmark, as it indicates the position occupied by the cartilaginous portion of the **tuba auditivae,** or *Eustachian tube.* The tube leads from the upper portion of the pharynx to the **cavum tympani,** or middle ear, and permits air to enter the latter cavity from the pharynx. In the macerated skull the student will experience little difficulty in passing a pin, or fine probe, along the sulcus tubae auditivae backwards and outwards into the cavum tympani. The pin traverses the bony portion of the tuba auditivae, and if the cavum tympani be examined by looking in through the meatus acusticus externus (see page 183) the pin's point may be recognized as it lies within the cavity.

The large posterior openings of the nasal chambers should now be examined. These, spoken of as the **choanae**, or *posterior nares*, lie close together on each side of the middle line, being separated only by the posterior portion of the thin **septum nasi**. The openings are directed backwards and slightly downwards, and lead, during life, from the nasal chambers into the upper part of the pharynx. The long axis of each opening is nearly vertical, and measures just one inch; the transverse diameter is a little more than half an inch. The lower boundaries of the choanae are formed by the thin posterior free edge of the hard palate; the outer boundaries correspond to the **laminae mediales** of the **processus pterygoidei**, or *internal pterygoid plates*, of the os sphenoidale; internally the openings are defined by the posterior edge of the **vomer**, forming a part of the septum nasi. Superiorly the outer and inner boundaries of the openings converge so as to form arch-like upper limits for the choanae. The vomer, as it is traced upwards, spreads out on each side to form the **ala vomeris**, which meeting with an inward projection, known as the **processus vaginalis**, from the lamina medialis processus pterygoidei, completes the upper boundary of the opening.

On looking in through the openings the student will easily recognize the **concha nasalis inferior**, and the **concha nasalis media**, scroll-like, delicate bony structures which pass inwards from the outer walls of the nasal chambers towards the septum nasi and imperfectly subdivide each nasal chamber. By carefully tilting the skull, a much smaller **concha nasalis superior** may be recognized within each nasal chamber; it lies above the concha media, and above the level of the upper boundary of the choana.

Immediately to the outer side of the opening into the nasal chamber lies a vertical groove-like depression, known as the **fossa pterygoidea**. This fossa lies between two bony laminae which are united in front, but diverge, and are free posteriorly. They form the **lamina medialis** and **lamina**

lateralis of the **processus pterygoideus**, or *internal* and *external pterygoid plates.* The processus pterygoideus is a portion of the os sphenoidale, and projects vertically down-

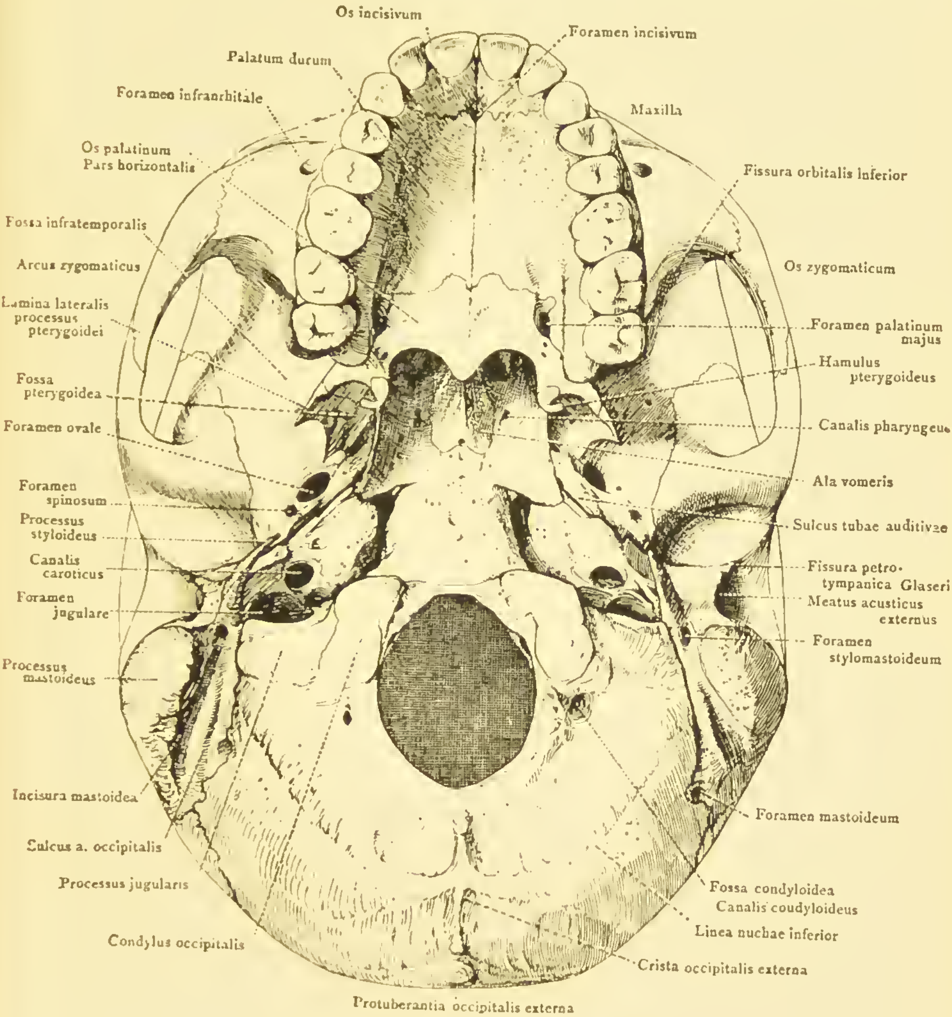

FIG. 121.—The skull from below.

wards from the base of the skull forming a buttress of support for the maxilla. It is composed of the two laminae just mentioned.

The **lamina medialis**, of the processus pterygoideus, is smaller and slightly longer than the lamina lateralis, and its posterior free border is continued into a slender, hook-like, curvèd process, the **hamulus pterygoideus**, which curves outwards and backwards on the inner side of the posterior end of the processus alveolaris of the maxilla. The hamulus serves as a pulley round which pulls the tendon of the tensor veli palatini. The wall of the upper part of the pharynx is attached to the free posterior edge of the lamina medialis of the processus pterygoideus, and the pharyngeal opening of the tuba auditiva is supported by it. The lamina medialis will be seen to lie between the nasal chamber and the fossa pterygoidea.

The **lamina lateralis** of the processus pterygoideus is larger, but not quite so long as the lamina medialis. It not only projects backwards but also outwards, and intervenes between the fossa pterygoidea and the fossa infra-temporalis, and takes part in the formation of each. By its inner and outer surfaces, the lamina lateralis gives origin to portions of the pterygoideus internus and externus muscles.

A careful examination of the fossa pterygoidea will show that its lower part is completed by a small triangular portion of the os palatinum, which is insinuated between, and unites the lower ends of the lateral and medial laminae of the processus pterygoideus. A small portion of the same bone will also be found to intervene between the maxilla and the lower part of the processus pterygoideus of the os sphenoidale. In old specimens, in which the sutures have become obliterated, it may not be possible to recognize the separation between the os palatinum and the laminae of the processus pterygoideus, but in the isolated os sphenoidale the notch, or **fissura pterygoidea**, which separates the lower ends of the lateral and medial laminae, and which in the entire skull is filled by a part of the os palatinum, is very conspicuous (figs. 124 and 128).

Before leaving the region of the processus pterygoideus we must again notice the scale-like plate, or **processus vaginalis**, which passes inwards from the inner side of the upper part of the lamina medialis, and arching over the posterior opening of the nasal chamber meets, and slightly overlaps the lateral edge of the ala of the vomer, holding it firmly in place. In relationship with the processus vaginalis a minute canal, the **canalis pharyngeus**, or *pterygo-palatine canal*, runs forwards into the upper and inner part of the fossa pterygo-palatina (see page 223 and fig. 124). Just where the upper end of the fossa pterygoidea reaches the base of the skull and to the outer side of the lamina medialis there is usually a slight depression, known as the **fossa scaphoidea**, which marks the origin of the tensor veli palatini muscle. The secure manner in which the vomer is held in place by the overlapping processus vaginalis has been noticed, and we shall see later on that the articulation is made the more secure by the inclusion of a median vertical projection of the sphenoid between the diverging alae of the vomer (fig. 134).

Fossa Infra-temporalis.—The region to the outside of the processus pterygoideus and in front of the fossa mandibularis is known as the **fossa infra-temporalis**, or *zygomatic fossa.* Its *upper wall*, or roof, is mainly formed by the under aspect of the ala magna of the os sphenoidale, and to a slight extent by the squama temporalis ; its *inner wall* corresponds to the outer side of the lamina lateralis processus pterygoidei ; its anterior wall is formed by the facies infra-temporalis of the maxilla which looks backwards and outwards into the fossa. Beneath the arcus zygomaticus the infra-temporal fossa communicates freely with the temporal fossa, the line of separation being a series of rough marks which form a ridge, the **crista infra-temporalis**, and give origin to tendinous fibres in the temporal muscle. This crest lies on the ala magna of the os sphenoidale, and posteriorly it can be traced into the anterior edge of the root of the processus zygomaticus of the os temporale.

The anterior part of the fossa infra-temporalis communicates with the orbit through the **fissura orbitalis inferior**, or *spheno-maxillary fissure.* Continuous with this fissure there is a vertical cleft leading from the fossa infra-temporalis into an interval known as the **fossa pterygo-palatina**, which lies between the maxilla and the anterior aspect of the processus pterygoideus. This latter cleft, often called the *pterygo-maxillary fissure*, is closed inferiorly by the part of the os palatinum which intervenes between the maxilla and the lower end of the processus pterygoideus. The cleft lies at the junction of the anterior and inner walls of the fossa infra-temporalis, and through it the arteria maxillaris interna leaves the fossa.

On the convex infra-temporal surface of the maxilla may be seen the openings, **foramina alveolaria**, of one or more minute canals for the transmission of the blood vessels to supply the upper molar teeth.

In the roof of the posterior part of the fossa infra-temporalis there are two important foramina, both of which pierce the ala magna of the os sphenoidale, and lead into the cranial cavity.

The larger of these, the **foramen ovale**, lies immediately behind the upper end of the posterior free border of the lamina lateralis processus pterygoidei, and transmits the great mandibular division and motor root of the trigeminus, or fifth cranial nerve, and a small meningeal vessel. The smaller, or **foramen spinosum**, lies in the spina angularis of the os sphenoidale, and through it the arteria meningea media, or middle meningeal artery, accompanied by some nerve filaments, enters the cranium. The under aspect of the bone forming the **spina angularis**, or *spine of the sphenoid*, projects downwards to a very variable extent and gives attachment to the ligamentum spheno-mandibulare, or internal lateral ligament of the temporo-mandibular joint.

During life the interval that lies on the inner side of the ramus mandibulae, and on the outer side of the lamina lateralis processus pterygoidei, is mainly occupied by the pterygoideus externus and internus muscles, the arteria maxillaris interna and the great branches of the mandibular division of the nervus trigeminus.

Before leaving the sphenoidal region of the under aspect of the skull the student should carefully trace the outline of the **os sphenoidale**, and note the lines along which it articulates with the pars petrosa, the squama temporalis, the os palatinum, and the vomer. The line of fusion of the body of the os sphenoidale, with the pars basilaris of the os occipitale, should also be determined by comparing an adult with a young skull. In our examination of the skull from the side, and of the orbital cavity, we have seen that the os sphenoidale also articulates with the os zygomaticum, the os parietale, the os frontale and the os ethmoidale. On an isolated os sphenoidale the areas for articulation with all of these should be examined and defined (see figs. 124, 127, and 128).

We shall complete our survey of the under aspect of the skull by examining the hard palate and the fossa pterygo-palatina.

THE HARD PALATE.

The **palatum durum**, or *hard palate*, is a horizontal bony shelf that intervenes between the nasal chambers above and the mouth cavity below. It is bounded at the sides and in front by the **processus alveolares** of the maxillae, which carry the teeth of the upper jaw and unite in front to form a U shaped curve. When these processes are well developed, they give the under aspect of the palatum durum a concave arched appearance:

but when they are absorbed, owing to the shedding of the teeth, the under surface of the palate no longer appears to be arched. The surface of bone forming the palate is rough, and pitted for the attachment of the thick periosteum and mucous membrane.

The anterior two-thirds of the palatum durum is formed by the **processus palatinus** of the right, uniting with the

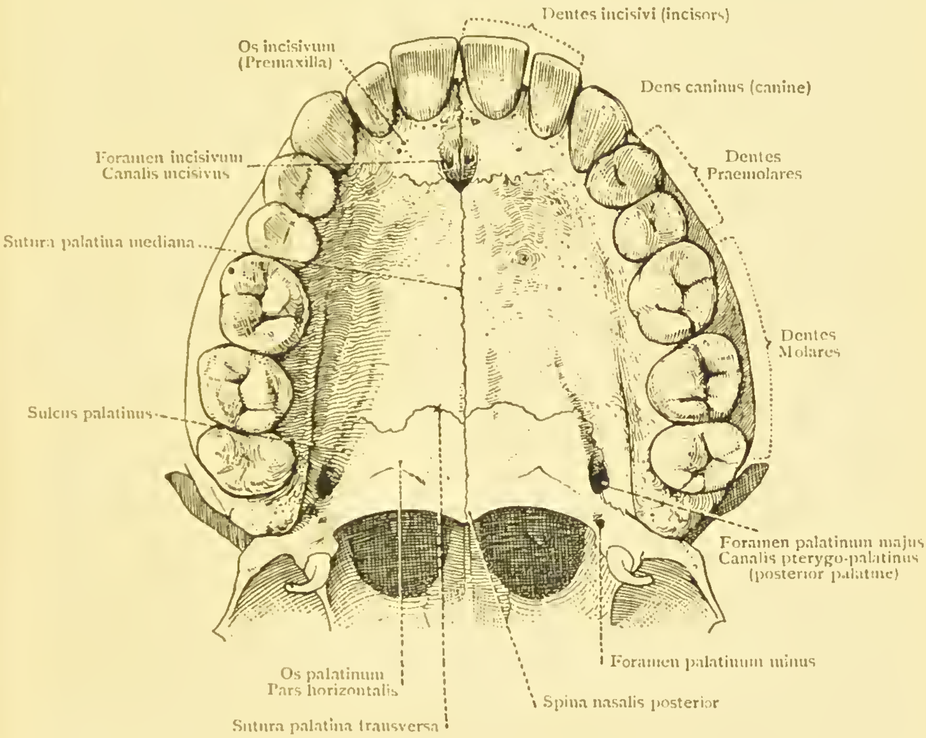

FIG. 122.—The hard palate from below.

corresponding process of the left, maxilla. The posterior third is formed by the union of the **partes horizontales** of the palate bones. In the middle line a continuous suture, known as the **sutura palatina media**, indicates the line of junction of these structures. A transverse suture, the **sutura palatina transversa**, passes outwards on each side and marks the union of the os palatinum with the maxilla. The posterior edge of the hard palate is free and sharp; in the middle line it is continued backwards to form the **spina nasalis posterior**, which lies just below the posterior edge of the vomer, where it separates the choanae. In the living subject the soft palate is fixed to the free edge of the hard palate.

The **foramen palatinum majus** will be seen, close to the processus alveolaris, on the outer and posterior part of the palatum durum. This foramen is the lower end of the **canalis pterygo-palatinus**, or *posterior palatine canal*, that transmits the great blood vessels and nerves of the palate. One or two grooves, the **sulci palatini**, bounded by sharp edges called the **spinae palatinae**, may be seen running forwards and slightly inwards, from the foramen palatinum majus. In these sulci lie the main branches of the arteries. One or more smaller foramina are usually present behind the foramen palatinum majus; they are named **foramina palatina minora.**

The anterior part of the sutura palatina media widens to form a pit-like interval, the **foramen incisivum**, or *anterior palatine fossa*, which lies in the middle line just behind the interval between the median incisor teeth. At the bottom of this pit a minute canal leads upwards, on each side, into the nasal chamber, and represents the much larger opening found in this position in the skulls of lower animals. The little canal is known as the **canalis incisivus**, and lies close to its fellow of the opposite side. Frequently one, or two, other minute openings are present occupying the middle line and leading upwards into the nasal chambers. In young skulls a fine suture may often be recognized passing outwards from the foramen incisivum towards the canine tooth. It indicates the posterior limit of the **os incisivum**, which forms a separate element in the early stages of the development of the skull, and represents the *premaxillary bone* of lower animals. Sometimes the part of the palate, which in the young subject corresponds to the os incisivum, is subdivided into inner and outer portions by a little suture which passes to the interval between the median and lateral incisor teeth (see fig. 147).

THE FOSSA PTERYGO-PALATINA.

The **fossa pterygo-palatina**, or *spheno-maxillary fossa*, is a deep cleft which intervenes between the maxilla in front and the processus pterygoideus behind. The opening into this fossa from the fossa infra-temporalis, often called the *pterygo-maxillary fissure*, is very narrow, especially in its lower part, where it is bounded by the approximation of the maxilla and the processus pterygoideus. We have already studied this opening, and we have seen that a small portion of the os palatinum is wedged in between the two bones where they come closest together (page 219).

The *inner wall* of the fossa pterygo-palatina intervenes between the fossa and the nasal chamber, and is formed by the pars perpendicularis of the os palatinum. It is pierced in its upper part by the **foramen spheno-palatinum** which leads into the nasal chamber where, as we shall see, it opens behind the posterior end of the concha media. The surface forming the inner wall should be examined in an isolated os palatinum.

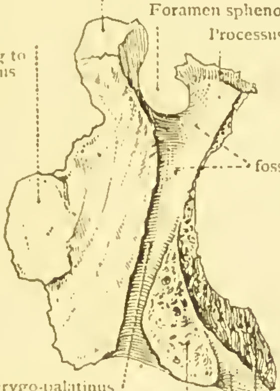

FIG. 123.—Left os palatinum from the outer aspect.

The *posterior wall* of the fossa is best seen when the isolated os sphenoidale is viewed from in front. It is formed by the anterior aspect of the root of the ala magna and the anterior surface of the processus pterygoideus. On the posterior wall are three openings :—(1) **foramen rotundum** leading backwards into the fossa cranii media, (2) **canalis pterygoideus**, or *Vidian canal*, which is directed backwards towards the foramen lacerum, and (3) the minute **canalis pharyngeus**, or *pterygo-palatine canal*, which runs backwards and lies, as we have already seen, just above the choana. Of these three foramina, the most important, the **foramen rotundum**, transmits the maxillary division of the nervus trigeminus. The **canalis pterygoideus**, transmits the continuation of the nervus petrosus superficialis major (from the facialis or seventh cranial nerve), which, in this part of its course, is often spoken of as the Vidian nerve (see fig. 124).

The narrow lower part of the fossa pterygo-palatina is continued into the **canalis pterygo-palatinus**, which opens on the posterior and outer part of the hard palate, at the **foramen palatinum majus**.

The fossa communicates with the orbit through the **fissura orbitalis inferior**.

An excellent idea of the extent of the fossa pterygo-palatina and of its walls may be obtained by examining isolated examples of the bones—os palatinum, os sphenoidale, and maxilla—which bound it, and by articulating these together so as to re-form the fossa. In the entire skull, bristles should be passed into the fossa through the various foramina mentioned above, as by this means the important connexions of the fossa pterygo-palatina can be satisfactorily demonstrated.

THE FLOOR OF THE CRANIUM.

The cranial cavity should be examined from above in a skull, the calvaria of which has been sawn off. The **basis cranii interna**, or *floor of the cranium*, is very uneven and it will be noticed that its level varies much in different parts. The deepest part, which lies posteriorly, behind and in the region of the foramen magnum, is known as the **fossa cranii posterior**. The floor of the anterior part of the cranium lies on the highest level and forms the **fossa cranii anterior.** The portion of the floor which lies between the anterior and posterior fossae is wide at each side and narrow near the middle line; it is called the **fossa cranii media**.

Fossa Cranii Anterior.—The fossa cranii anterior lies above the orbital cavities and the nasal chambers. Its floor is formed on each side by the thin **pars orbitalis**, or *orbital plate*, of the **os frontale**, and towards the middle line by the **lamina cribrosa** of the **os ethmoidale**. More posteriorly, each half of the floor is completed by the **ala parva**, and by a part of the **corpus ossis sphenoidalis**.

The **pars orbitalis** is a thin bony plate, convex upwards towards the cranial cavity, and marked by a number of smooth elevations, which correspond in position to the fissures on the over-lying orbital surface of the frontal lobe of the cerebrum. The under surface of this plate has already been seen forming the arched roof of the orbit.

The left pars orbitalis is separated from the right by a portion of the os ethmoidale. This consists of a conspicuous laterally

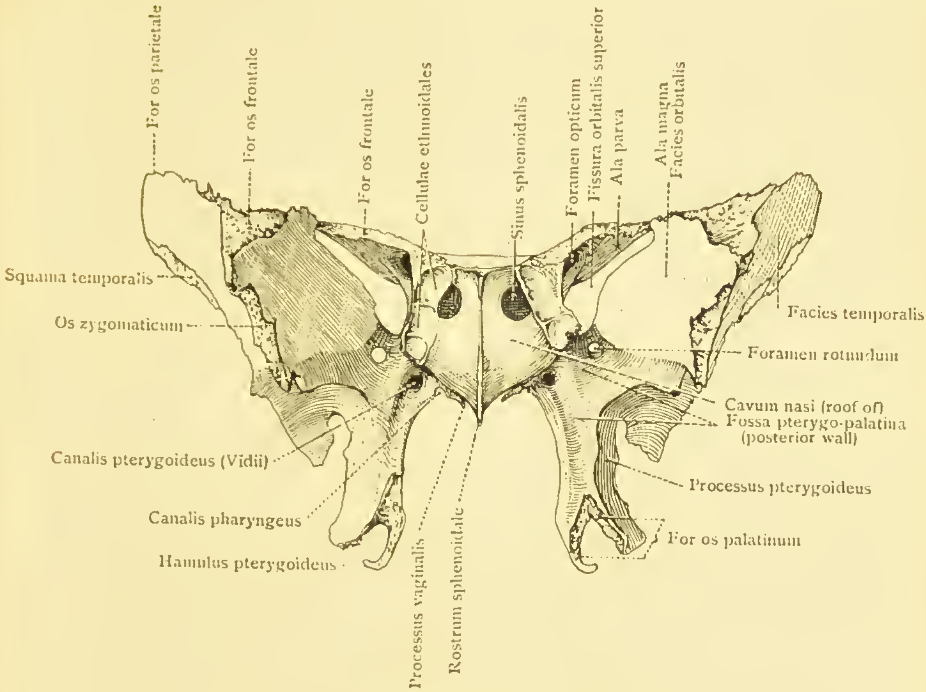

FIG. 124.—Os sphenoidale from in front.

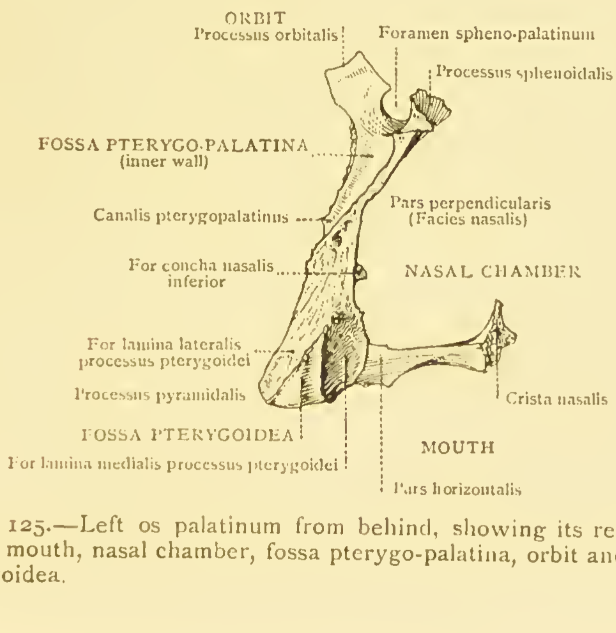

FIG. 125.—Left os palatinum from behind, showing its relations to the mouth, nasal chamber, fossa pterygo-palatina, orbit and fossa pterygoidea.

compressed, upwardly directed process, known as the **crista galli**, and of a narrow depressed area on each side of it formed by the lamina cribrosa. The crista galli gives attachment to the lower part of a great vertical fold of the dura mater, the falx cerebri, which occupies the mesial plane in the upper part of the cranial cavity, and lies between the hemispheres of the cerebrum. The **lamina cribrosa** is an extremely fragile plate that intervenes between the anterior cranial fossa and the upper narrow part of the nasal chamber. The olfactory bulb rests upon it during life, and the numerous foramina which pierce it transmit the olfactory nerves.

A careful examination along the outer edge of the lamina cribrosa will reveal two minute openings which lead into the orbit. These are the **foramina ethmoidalia**, or *internal orbital canals*, already recognized, leading from the orbit at the junction of its roof and inner wall. We have already noticed that the **foramen ethmoidale posterius** affords a passage for the posterior ethmoidal artery, and that the more important **foramen ethmoidale anterius** transmits the anterior ethmoidal artery and the continuation of the nervus naso-ciliaris, or nasal nerve (a branch of the ophthalmicus division of the nervus trigeminus). The student should now seek, at the side of the crista galli, a small slit-like opening leading into the nasal chamber for the nasal nerve.

The nasal nerve, which carries sensory impulses from the mucous membrane of the nose, enters the cranium through the slit at the side of the crista galli, leaves the fossa cranii anterius, to enter the orbit, through the foramen ethmoidale anterius, and finally passes backwards within the orbit, to enter the fossa cranii media through the fissura orbitalis superior. The complicated course pursued by this nerve can thus be readily traced in the skull. Within the nasal chamber the continuation of the nerve lies in a narrow and shallow sulcus, which may be seen on the posterior aspect of the os nasale, by looking in through the apertura piriformis.

Immediately in front of the crista galli, a small foramen, the **foramen caecum**, may usually be found in the middle line. It transmits a small vein from the nasal cavity. In front of this foramen the os frontale is continued across the floor of the fossa cranii anterior. Here, in the middle line the bone is raised to form a ridge, called the **crista frontalis**, which, like the crista galli of the os ethmoidale, affords attachment to the falx cerebri.

Except in old skulls, a transverse suture may be traced

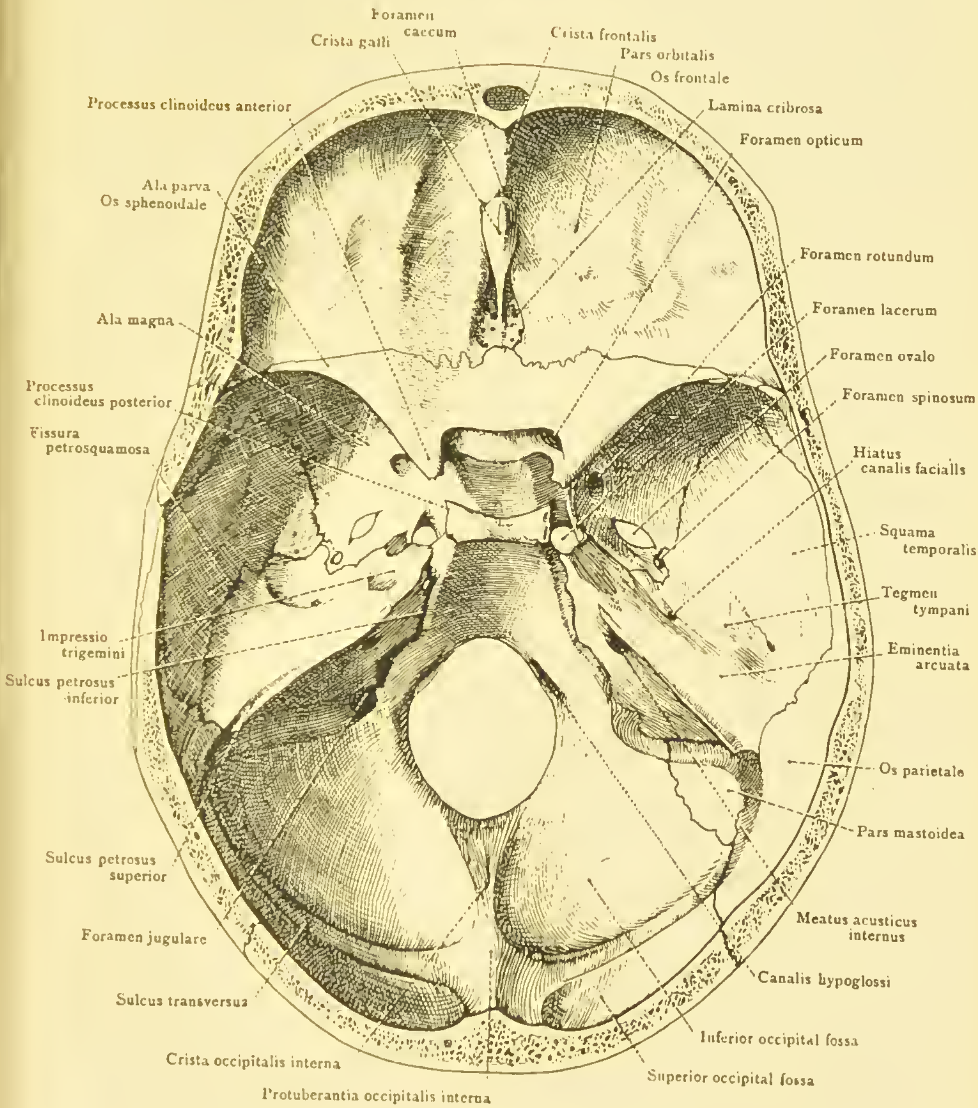

FIG. 126.—Floor of the cranium.

across the posterior part of the floor of the anterior cranial fossa. This suture, the **sutura spheno-orbitalis**, defines the anterior edge of the ala parva and also the anterior edge of the upper surface of the body of the os sphenoidale. On each side it separates the os sphenoidale from the pars orbitalis of the os frontale, and near the middle line it intervenes between the os sphenoidale and the os ethmoidale.

The upper, or cranial, surface of the **ala parva**, or lesser wing, of the **os sphenoidale**, is smooth and flat. It has the form of an elongate triangle with the apex directed outwards. Its *posterior border* is free, thin and sharp, and so curved as to be concave backwards; it forms the line of separation between the fossa cranii anterior and the fossa cranii media in their lateral parts. Internally the posterior border ends at a flattened, backwardly directed process, known as the **processus clinoideus anterior.** The smooth flat area of the os sphenoidale, which intervenes between the right and the left ala parva, is related, on each side, to the orbital surface of the frontal lobe of the cerebrum where the olfactory tract joins the brain.

Fossa Cranii Media.—The anterior edge of the *median part* of the fossa cranii media is often ill-defined; it lies behind the smooth area just mentioned, and approximately corresponds to a line drawn transversely through the anterior and inner part of each processus clinoideus anterior.

Just in front and to the inner side of the processus clinoideus anterior, the os sphenoidale is pierced by a short canal, which leads forwards and outwards into the deepest part of the orbit. This canal is known as the **foramen opticum**, and transmits the nervus opticus and the arteria ophthalmica into the orbital cavity, where its anterior end has been already recognized. Within the cranial cavity a shallow sulcus, the **sulcus chiasmatis**, or *optic groove*, extends between the right and left optic foramina, and the anterior wall of the sulcus is regarded as the line of separation between the median portions of the anterior and middle cranial fossae. The optic commissure which connects the optic nerves lies close to, if not in contact with, this sulcus.

The smooth transverse elevation which is crossed by the sulcus chiasmatis is known as *olivary eminence*, or **tuberculum sellae.** It forms the anterior boundary of an important depression which lodges a remarkable structure known as the hypophysis, or pituitary body. This depression is called the

fossa hypophyseos, or *pituitary fossa*, and is just large enough to receive the tip of the little finger. Posteriorly, it is limited by a nearly vertical plate of bone named the **dorsum sellae**, which, like the other boundaries for the fossa, is a part of the os sphenoidale. The upper edge of the dorsum sellae ends, on each side, in a little tubercle known as the **processus clinoideus posterior**, which lies not far from the processus clinoideus anterior to which, in some cases, it is

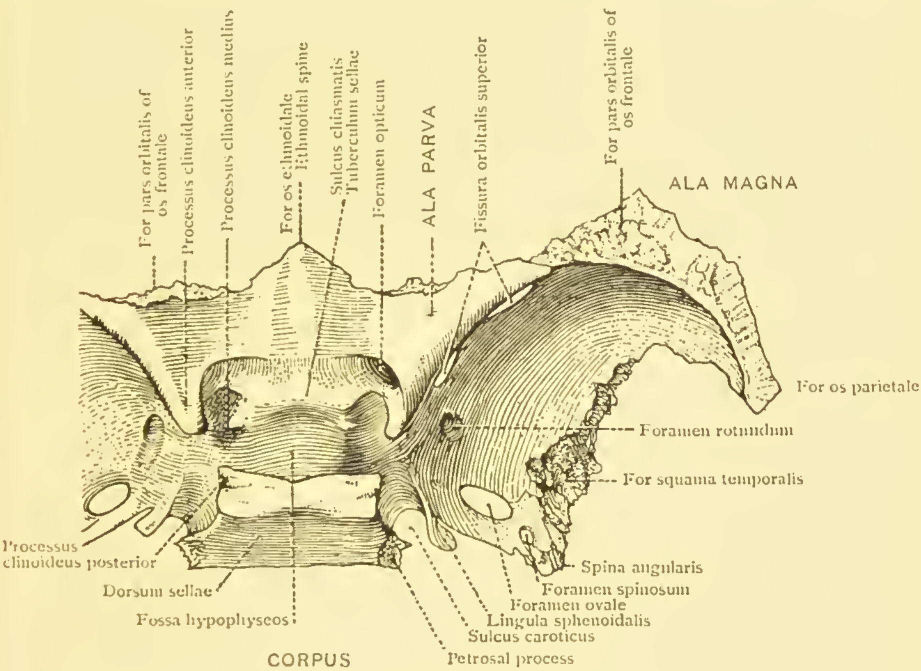

FIG. 127.—Os sphenoidale from above.

united by a bar of bone. In many skulls a little conical elevation may be seen rising from the floor of the cranium just behind, and to the inner side of the processus clinoideus anterior. It is called the processus clinoideus medius, and when strongly developed, may be united by its apex with both the other clinoid processes. The small *median portion* of the **fossa cranii media** is composed of the sulcus chiasmatis and the pituitary fossa just described, and is formed entirely by the corpus ossis sphenoidalis.

The floor of the *lateral portion* of the **fossa media** is formed, in its anterior and inner part, by the **ala magna** of the **os sphenoidale**, and more posteriorly and laterally, by the **pars petrosa** and the **squama** of the **os temporale.** This part of the fossa media is bounded in front by the sharp posterior border of the ala parva of the os sphenoidale, and posteriorly by the *upper border*, or **angulus superior**, of the pars petrosa of the os temporale. The latter boundary runs forwards and inwards towards the dorsum sellae, and with it completes the separation of the fossa cranii media from the fossa cranii posterior. The lateral portion of the fossa media lodges the temporal lobe of the cerebrum, and in many places its floor is marked by smooth elevations and depressions which correspond to the sulci and convolutions of that part of the brain.

The anterior end of the fossa lies behind the orbit, with which it communicates by the **fissura orbitalis superior**, or *sphenoidal fissure.* This cleft will be found immediately under the free posterior border of the ala parva and separates the latter from the ala magna of the os sphenoidale. The inner end of the fissure is wide and rounded; its outer end narrow and pointed. We have already noticed its position with regard to the roof and outer wall of the orbit, and we have seen that it transmits the ophthalmic veins and many important nerves; these latter are the branches of the ophthalmicus division of the nervus trigeminus, the nervus oculomotorius, the nervus trochlearis and the nervus abducens. The last three nerves supply the muscles in connexion with the eyeball; the first-named is a sensory nerve.

Immediately below the wide inner end of the fissura orbitalis superior, the student should seek the opening of a canal which leads directly forwards through the inner part of the ala magna of the os sphenoidale. This canal is known as the **foramen rotundum**, and its anterior end lies in the fossa pterygo-palatina, where it has already been recognized (page 223). Through it passes the important maxillary division of the nervus trigeminus which ends in the nervus infra-orbitalis, whose course, in relation to the orbit, we have already followed. In the entire skull, owing to the depth and narrowness of the fossa pterygo-palatina, it is always difficult, and often impossible, to recognize the anterior end of the foramen rotundum, but in some cases it may be seen by looking from the orbit backwards through the fissura orbitalis inferior into the fossa pterygo-palatina. In the isolated os sphenoidale the anterior end of the foramen rotundum is very conspicuous (fig. 124).

Behind and to the outer side of the foramen rotundum, lies the larger **foramen ovale**, which leads vertically from the fossa cranii media to the fossa infra-temporalis, where its lower aspect has already been recognized. It transmits the great mandibular division of the nervus trigeminus with which also passes the motor roots of the same nerve, for the supply of the muscles of mastication.

A little further backwards and outwards lies the much smaller **foramen spinosum**, for the passage of the arteria meningea media. The lower part of this foramen has also

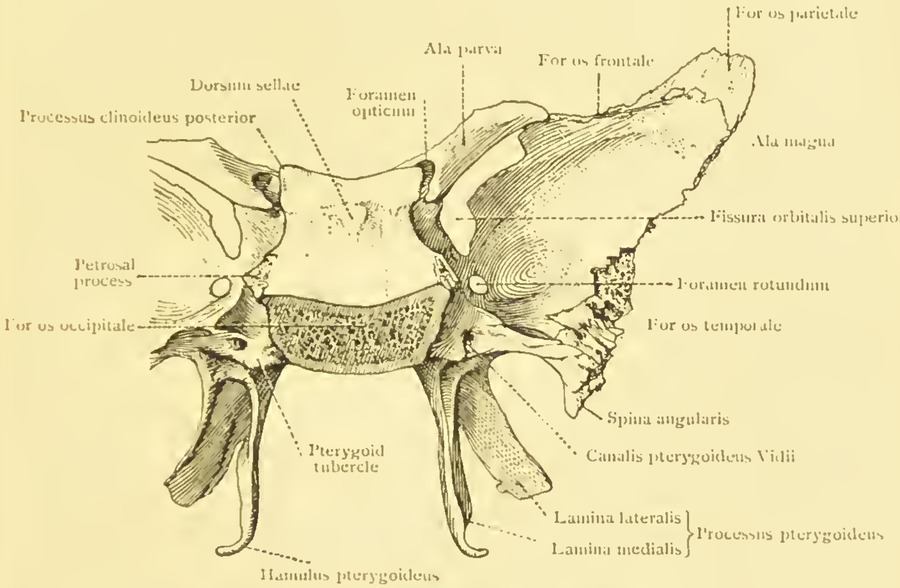

FIG. 128.—Os sphenoidale from behind.

been seen in the roof of the fossa infra-temporalis piercing the spina angularis of the os sphenoidale. When viewed from above, the foramen is seen to lie in the extreme posterior part of the ala magna of the os sphenoidale, which is wedged into the angular interval between the squama and the pars petrosa of the os temporale.

In his examination of the cranial floor the student should carefully note the form of the **ala magna** of the **os sphenoidale**, and recognize that it separates the fossa cranii media from, (1) the orbit which lies in front and to its inner side, (2) the fossa temporalis which lies to its outer side, and (3) the fossa infra-temporalis which lies below. The root of the ala magna also intervenes between the fossa cranii media and the fossa pterygo-palatina. Except in the case of the fossa pterygo-palatina the surfaces of the ala magna which look into these various fossae can be examined in the entire skull. The latter only can be studied satisfactorily in the isolated os sphenoidale (see fig. 124).

At the side of the body of the os sphenoidale, in the region where the median part of the fossa cranii media joins the lateral subdivision, is a shallow sulcus, the **sulcus caroticus.** This sulcus begins posteriorly at the anterior end of the foramen lacerum, where the internal carotid artery enters the cranial cavity between two small backwardly projecting processes of the os sphenoidale. The outer and more slender of these is known as the **lingula sphenoidalis**; the inner as the *petrosal process* of the os sphenoidale. When well-developed, these two processes almost enclose a foramen for the artery (see fig. 127). Having entered the cranium the artery runs upwards and then forwards, along the side of the body of the os sphenoidale, until it reaches the region of the processus clinoideus anterior, on the inner side of which it turns vertically upwards. The sigmoid course of the shallow sulcus should be carefully studied, and its relationship to the pituitary fossa and clinoid processes determined. It will be noticed that the artery passes on the outer side of the processus clinoideus medius when the latter is present. The artery, in this part of its course, lies in a cleft in the dura mater which also contains a large blood sinus, the sinus cavernosus, and the nerves passing to the fissura orbitalis superior.

We shall next examine the part of the floor of the fossa cranii media formed by the **os temporale.** The **squama temporalis** forms the outer and anterior part, and the **pars petrosa** the inner and posterior portion (fig. 126).

The long axis of the **pars petrosa** is directed forwards and inwards, and its blunt apex lies immediately behind the foramen lacerum. The surface, **facies anterior**, which looks into the fossa media, is very smooth and hard, and is directed forwards and upwards. On this surface, near the apex of the bone and just above the canalis caroticus, there is a shallow depression called the **impressio trigemini**, in which lies the great ganglion connected with the nervus trigeminus. Much further back the smooth surface of the bone is raised to form a very variable elevation, the **eminentia arcuata**, beneath which lies the superior semicircular canal of the internal ear. Somewhere between these two markings, a minute opening will be found leading backwards and outwards into a little canal, which joins the bony canal for the nervus facialis. This little opening is known as the **hiatus canalis facialis**, or '*hiatus of Fallopius*', and through it passes the nervus petrosus superficialis major, or great superficial petrosal nerve, a small sensory branch of the nervus facialis, which leaves the cranium by traversing the cartilage occupying the foramen lacerum, and finally becomes the Vidian nerve, whose course in relation to the os sphenoidale we have already seen (page 223). To the outer side of the hiatus another even more minute foramen may usually be recognized.

In front of the eminentia arcuata, and to the outer side of a line joining it and the hiatus, a flat narrow area of the pars petrosa forms the roof of the middle ear, or **cavum tympani**. The bone in this area is formed by a very thin plate known as the **tegmen tympani**, and it is continued backwards and outwards to roof the **antrum tympanicum**, or *mastoid antrum*. It is important to bear in mind that these two air cavities are separated from the fossa cranii media merely by the thin plate forming the tegmen tympani.

In the young skull the cranial aspect of the squama temporalis is separated from that of the pars petrosa by a well-defined suture, the **sutura petro-squamosa**. In the adult a part of this suture may be seen passing backwards and outwards from the notch between the squama and pars petrosa, to the notch between the squama and pars mastoidea (figs. 126 and 130).

On the cranial aspect of the **squama temporalis**, a groove for the middle meningeal artery may be seen running upwards and outwards from the region of the foramen spinosum. This groove, the **sulcus arteriosus**, ascends nearly parallel to the anterior border of the squama, and gives off one or more branches which sweep backwards and upwards. The depressions for the convolutions for the temporal lobe of the brain are very distinct on the part of the floor of the fossa cranii media formed by the squama temporalis.

The well-defined edge separating the fossa cranii media from the fossa cranii posterior is known as the *superior border*, or **angulus superior** of the pars petrosa. It gives attachment to one edge of a remarkable fold of dura mater, the tentorium cerebelli, which roofs over the fossa cranii posterior. The line of attachment of this fold is continued forwards and inwards as far as the processus clinoideus posterior; and backwards along the groove for the great sinus transversus, or lateral sinus, to the median plane. The tentorium cerebelli has a curved anterior free margin which bounds, during life, the opening leading from the posterior into the middle cranial fossa. This free edge is attached on each side to the processus clinoideus anterior. It is important that the student should at this stage carefully examine the arrangement of this fold of the dura mater in a dried specimen, such as may be found preserved in most anatomical museums.

A narrow groove, the **sulcus petrosus superior**, runs along the edge of the pars petrosa which gives attachment to the tentorium cerebelli. In this lies the sinus petrosus superior which communicates in front with the sinus cavernosus, already mentioned, and behind with the sinus transversus.

Fossa Cranii Posterior.—The fossa cranii posterior is the deepest of the three cranial fossae. It lies below the level of the sulcus petrosus superior, and the dorsum sellae, which together form its anterior limits. Posteriorly it lies below the plane determined by the **sulcus transversus**, which marks the occipital bone and indicates, on each side, the position occupied by the sinus transversus, or lateral blood sinus.

With the exception of the part in front of the foramen magnum, the fossa cranii posterior is occupied by the cerebellum, the right and left hemispheres of which lie one on each side of the posterior part of the foramen. Behind the foramen magnum there is a median smooth ridge, the **crista occipitalis interna**, to which is attached a fold of the dura mater, the falx cerebelli, that occupies a median cleft between the hemispheres of the cerebellum. The wide region on each side of the crista occipitalis interna is smooth and concave, and is known as the *cerebellar fossa*; it is mainly formed by the os occipitale, but it is completed by the deep aspect of the pars mastoidea and by a portion of the pars petrosa of the os temporale.

In front of the foramen magnum, the floor of the fossa cranii posterior slopes forwards and upwards to the upper edge of the dorsum sellae. This part of the floor, concave from side to side, is termed the **clivus**. It is in relationship to the medulla oblongata and more intimately to the pons (Varoli), and is formed by the **pars basilaris** of the os occipitale and by the posterior part of the **corpus ossis sphenoidalis**. The line of union of these bones is usually obliterated shortly after the twentieth year.

The large size and the oval outline of the **foramen magnum** have been described already, and we have noted that many important structures pass through this opening, viz., the junction of the medulla oblongata and the spinal cord, the vertebral arteries, the accessory (or spinal accessory) nerves and several small blood-vessels.

On each side of the foramen magnum, the student should seek the beginning of the **canalis hypoglossi** (anterior con-

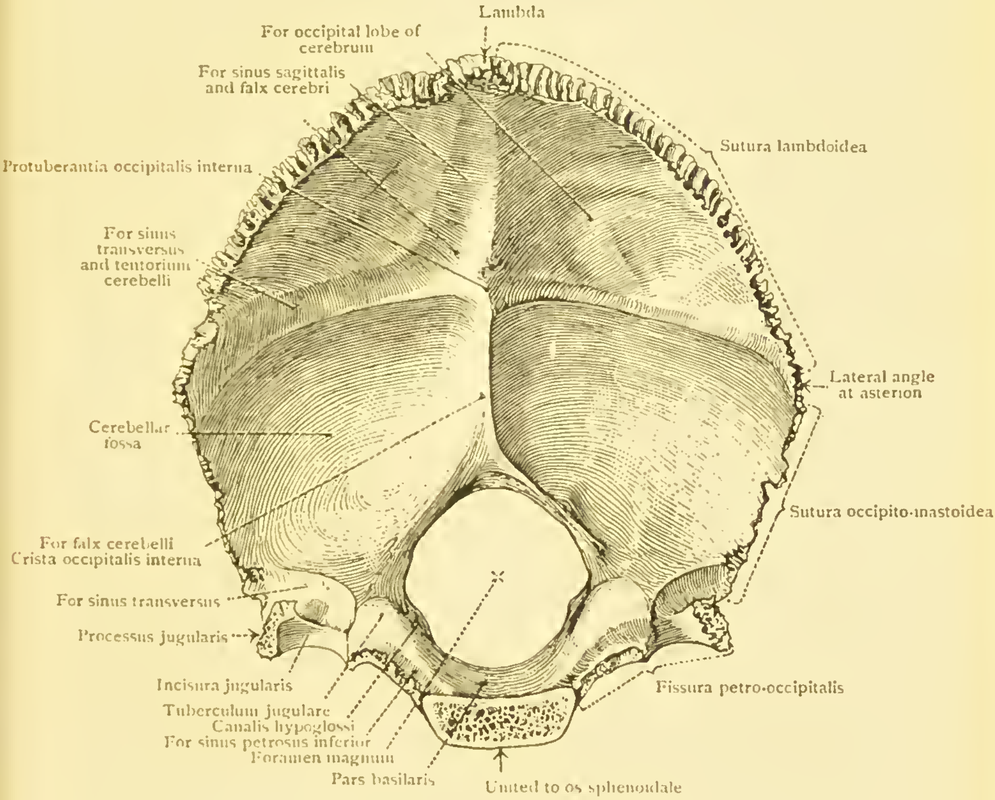

FIG. 129.—Os occipitale, cranial aspect.

dylar foramen) for the hypoglossal nerve. This opening is easily overlooked, as it opens forwards and outwards under cover of a smooth convexity, known as the **tuberculum jugulare**, and is not apparent when the base of the cranium is looked at directly from above. On inverting the cranium it becomes evident that the tuberculum jugulare lies vertically over the condylus occipitalis, the base of which is pierced by the canalis hypoglossi.

The **foramen jugulare** will be found at the outer side of the tuberculum jugulare and, passing downwards and forwards to reach it, the great sulcus for the sinus transversus will be recognized. We have already seen that the sinus passes out through the wide posterior part of the foramen jugulare and becomes the vena jugularis interna. A very much smaller sulcus, the **sulcus petrosus inferior**, will be recognized running along the outer edge of the pars basilaris ossis occipitalis, to reach the anterior part of the foramen jugulare. It lodges the sinus petrosus inferior which leaves the cranial cavity through the small anterior compartment of the foramen jugulare. The middle part of the foramen jugulare transmits, as we have seen, the glosso-pharyngeus, vagus and accessorius (spinal accessory) nerves. The appearance of the foramen jugulare varies much in different specimens, and sometimes it is subdivided by spicules of bone into three compartments for the structures which pass through it.

The anterior part of the outer wall of the fossa cranii posterior is formed by the almost vertical **facies posterior** of the **pars petrosa ossis temporalis.**

On this surface an important opening will be seen leading directly outwards. This is the opening of the **meatus acusticus internus**, or *internal auditory meatus*, into which pass the nervus acusticus, or auditory nerve, and the nervus facialis. The first-named nerve is the nerve of hearing, or eighth cranial nerve. It supplies the parts of the internal ear, or labyrinth, namely the cochlea, vestibule and semi-circular canals. These form the organ of hearing and the organ for the maintenance of equilibrium, and lie embedded in the dense bone of the pars petrosa. The nervus facialis, or seventh cranial nerve, is the great nerve of supply for the muscles of the face, and we have seen already that it leaves the os temporale by passing out of the foramen stylo-mastoideum, on the under aspect of the skull.

In its course through the os temporale, the nervus facialis runs in a bony canal, the **canalis facialis** (Falloppii), which has a very complicated arrangement, and may be said to begin at the bottom of the meatus acusticus internus, and to end at the foramen styló-mastoideum. It is usually possible to pass a piece of fine waxed twine along the course of this canal, from the opening at the bottom of the meatus internus to the foramen stylo-mastoideum. Two small branches of the nervus facialis leave the nerve as it lies in the bony canal and reach the surface of the os temporale. One of these, the nervus petrosus superficialis major, passes through the hiatus canalis facialis (see p. 233); and the other, the chorda tympani, through the inner part of the fissura petro-tympanica (see page 213). Both these slender nerves are sensory branches of the facialis. The main nerve as it leaves the foramen stylo-mastoideum is motor. As the nervus facialis enters the meatus acusticus internus it is accompanied by a slender nerve, known as the pars intermedia, which constitutes its sensory root.

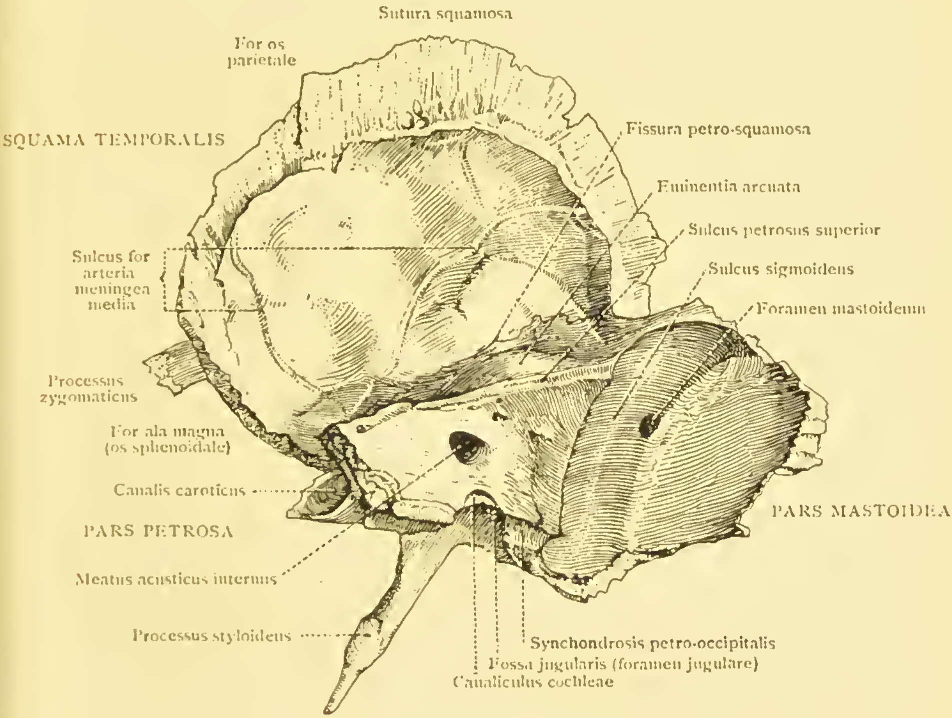

FIG. 130.—Right os temporale from the inner aspect.

Behind the opening of the meatus acusticus internus, there is a slit-like depression from the bottom of which a minute canal, the **aquaeductus vestibuli**, leads into the vestibule of the internal ear. Owing to the overhanging of its upper wall, it is difficult to see this opening unless the posterior aspect of the pars petrosa is viewed from below and behind.

In some cases the opening of the **canaliculus cochleae**, already noted, may be recognized at the outer edge of the foramen jugulare when the floor of the cranium is examined from above.

Before completing his study of the fossa cranii posterior, the student should follow carefully the course of the sulcus, which indicates the direction of the sinus transversus. The groove leads, as we have seen, to the posterior wall of the foramen jugulare. Tracing it backwards, it crosses the upper cranial surface of the **processus jugularis** of the os occipitale, and turns outwards to reach the deep aspect of the pars mastoidea of the os temporale. Here the groove is usually very deep, and runs a sigmoid course, as the **sulcus sigmoideus**, upwards and outwards to reach the region of the *asterion*, where it passes on to the extreme lower and posterior part, or angulus mastoideus, of the os parietale. From this point onwards the groove runs horizontally inwards, as the **sulcus transversus**, marking the ridge of bone, which gives attachment to the tentorium cerebelli and indicates the upper edge of the fossa cranii posterior. Reaching the middle line the ridge joins its fellow of the opposite side, and forms an elevation known as the **protuberantia occipitalis interna**. Here the right and left sulci may unite, or, more frequently, the right sulcus transversus bends to form a right angle, and is continued upwards in the middle line, as the **sulcus sagittalis**, marking the course of the sinus sagittalis superior, or superior longitudinal sinus. In some cases it is the left sulcus, marking the course of the left sinus transversus, which is continuous with the sulcus sagittalis for the sinus sagittalis superior. The right and left sulci are often of very unequal size, the right being usually the larger. The falx cerebri is attached along the edges of the sulcus sagittalis.

In the isolated os occipitale, the cruciform arrangement of the ridges for attachment of the tentorium cerebelli, the falx cerebelli, and the falx cerebri, is very striking, and leads to the separation of the four fossae ; the lower two being the *cerebellar fossae*, and the upper two lodging the occipital lobes of the cerebrum. These latter lie above the tentorium cerebelli, and above the fossa cranii posterior.

The **foramen mastoideum** usually begins on the floor of the sulcus sigmoideus, and piercing the bone obliquely, opens on the outer aspect of the skull behind the processus mastoideus.

THE SKULL IN SAGITTAL SECTION.

The arrangement of many parts of the skull is best displayed in sagittal section. In making such a section it is best to plan the path of the saw-cut, so that it shall occupy nearly, but not exactly, the mesial plane. By this means a good view may be obtained of the nasal septum in one half, and of the outer wall of the nasal chamber in the other.

An examination of such a section gives an excellent idea of the relative sizes of the facial and cranial portions of the skull; the position of the face below and in front of the cranial cavity is also strikingly demonstrated.

The cut surface of the cranial vault shows that the flat bones of the cranium consist of outer and inner layers of compact bone, separated by an intermediate layer of cancellous tissue. This latter is known as the **diploë**, and during life the enclosed spaces are filled with red marrow. The layers of compact tissue are known as the **lamina interna** and **externa**, or *inner* and *outer tables*.

In the frontal region, large air sinuses usually separate the inner and outer compact layers of bone, and the irregularly shaped cavities formed by them should be carefully explored. Each **sinus frontalis** extends upwards in the anterior cranial wall for a variable distance, and is usually prolonged backwards in the inner part of the roof of the orbita. The sinuses are rarely symmetrical, and often cross the median plane, so that both right and left sinuses are opened in a median sagittal section. It will be noticed that the size of the sinus is not necessarily dependent upon the development of the glabella and arcus superciliaris, but that frequently a large sinus is met with in a skull with a nearly vertical os frontale. The sinus frontalis opens inferiorly into the meatus nasi medius of the nasal chamber.

The extreme thinness of the **lamina cribrosa** of the os ethmoidale, forming the separation between the fossa cranii anterior and the nasal chamber, is well seen; it will be recognized that in this locality we have the thinnest and most fragile part of the cranial wall.

Large air sinuses occupy much of the **corpus ossis sphenoidalis**. and often extend backwards into the occipital bone. These sinuses are rarely symmetrical, one being usually considerably larger than the other, and crossing the median plane. They are separated by a very thin bony lamina, and each opens by a rounded aperture into the upper and back portion (recessus spheno-ethmoidalis) of the nasal chamber. Like the frontal sinuses they are lined, during life, by mucous membrane continuous with that of the nose. The close relationship of the **sinus sphenoidalis** to the fossa hypophyseos, or pituitary fossa, should be recognized.

As cut in section, the part of the floor of the cranial cavity which lies in front of the foramen magnum consists of (1) a steep ascending part, corresponding to the clivus, formed by the pars basilaris of the os occipitale and the dorsum sellae; (2) a well-defined depression, forming the pituitary fossa; and (3) a horizontal portion formed by the anterior part of the

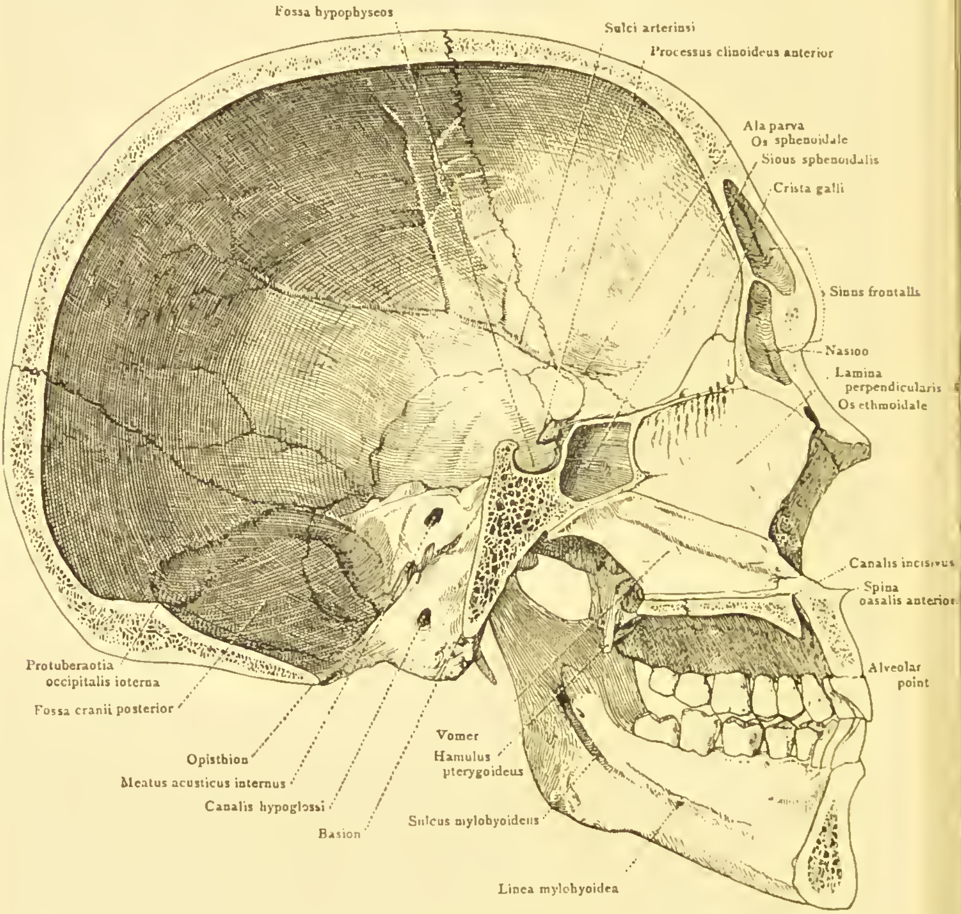

FIG. 131.—Skull in mesial section.

corpus ossis sphenoidalis and the os ethmoidale. The foramen magnum lies between points known as the *basion* in front and the *opisthion* behind. In the skulls of white races a line joining these two points lies horizontally, or is directed backwards and very slightly downwards.

Many of the markings in the fossa cranii posterior are well seen; among these are the cerebellar fossa, the canalis hypoglossi, the meatus acusticus internus, the foramen jugulare, the sulcus petrosus superior, the sulcus petrosus inferior, and the sulcus sigmoideus. The opening of the foramen mastoideum leading from the latter sulcus should be noted. The minute openings of the aqueductus vestibuli, and of the canaliculus cochleae, may also be recognized.

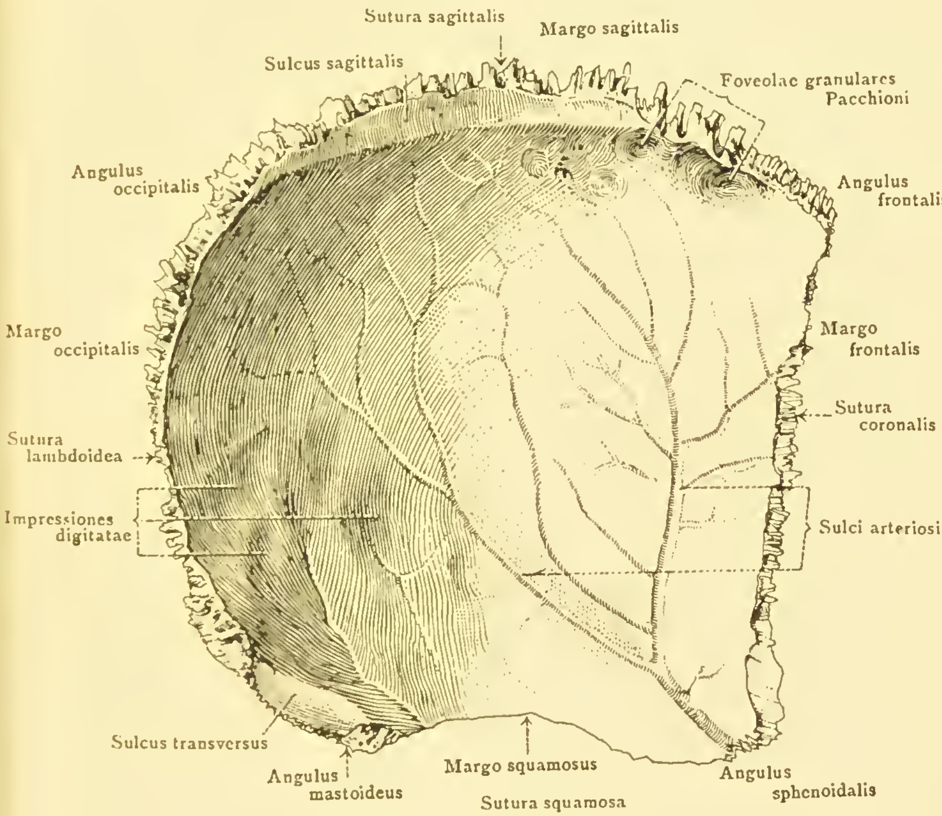

FIG. 132.—Left os parietale, cranial aspect.

The deep surfaces of the cranial bones which lie in relation to the cerebrum are marked by smooth depressions, **impressiones digitatae**, for its convolutions. These are better seen in the floor of the anterior and middle cranial fossa than higher up near the cranial roof. They are readily appreciated by passing the tips of the fingers over the deep surface of the os frontale and the os parietale, or of the os temporale and the os occipitale, where these latter bones are related to the cerebrum.

The branching grooves for blood-vessels, or **sulci arteriosi**, are very conspicuous. These are most strongly marked on the deep aspect of the os parietale, and correspond to the branches of the middle meningeal vessels. A large branch of the arteria meningea media reaches the anterior and lower part of the os parietale at its angulus sphenoidalis, and then runs upwards and backwards dividing into smaller branches, which diverge from one another at acute angles. One large branch usually ascends a short distance behind, and nearly parallel to, the sutura coronalis. The blood-vessels which occupy these grooves are important, as they are often torn in fractures of the cranial wall and, bleeding freely, cause compression of the brain. Their course, beginning at the foramen spinosum, across the floor of the lateral part of the fossa cranii media and then upwards and backwards on the side wall of the cranium, should be carefully followed. Other very much smaller systems of branching grooves may be found in the regions in front, and behind that occupied by the middle meningeal vessels.

Close to the cut edge of the calvaria, the **sulcus sagittalis** for the sinus sagittalis (superior longitudinal) should be recognized. It begins in front as a minute groove on the crista frontalis, and may sometimes be traced along this to the foramen caecum. The sulcus increases rapidly in width, as it is traced backwards along the middle line of the calvaria, and at the eminentia occipitalis interna it usually turns to the right and becomes continuous with the right sulcus transversus.

In the region just in front of the lambda a small **foramen parietale** may usually be found, leading from the sulcus sagittalis through the parietal bone.

Near the sulcus sagittalis, there are generally a series of pit-like depressions on the deep surface of the os parietale. These are called **foveolae granulares**, and lodge peculiar processes of the arachnoidea known as the granulationes arachnoideales, or Pacchionian bodies. When the foveolae are deep, as is often the case in the crania of aged persons, they almost penetrate to the outer surface of the calvaria.

The lines of the *sutures* uniting the cranial bones should be followed, as they appear on the deep aspect of the cranial wall. It will be noticed that they form wavy lines, and are in marked contrast to the complicated serrated lines, which indicate the junction of the cranial bones on the external surface of the calvaria. Further, a comparison of the outer with the inner aspect of the cranial wall will show that the position of the sutures on the two do not accurately agree. This is due to the fact that the edges of the bones are bevelled in a remarkable manner, and that each bone overlaps, or is overlapped by, its neighbours to an appreciable extent. This overlapping is perhaps best seen at the sutura squamosa, where the squama temporalis overlaps the lower border of the os parietale, and causes the outer to be considerably larger than the deep aspect of the squama. A similar condition may be noticed in the case of the ala magna of the os sphenoidale, where it joins the lower border of the os parietale. At the upper part of the sutura coronalis, the os frontale overlaps the os parietale, and in the lower part of the same suture the conditions are reversed, and the os parietale overlaps the os frontale. At other sutures overlapping may also be recognized, and wherever it is present, the condition adds enormously to the strength of the union between the cranial bones.

Before completing his study of the deep aspect of the cranial wall the student should identify, in the sagittal section of the skull, the various foramina he has already seen in the upper view of the basis cranii, and recall to mind the different structures which pass through each.

Septum Nasi.

The bony portion of the septum nasi should now be examined. It is mainly composed of two thin plates, one, the **lamina perpendicularis** of the **os ethmoidale**, forms the upper and anterior part; the other, the **vomer**, forms the lower and posterior part. These two plates are united along a line which passes downwards and forwards, from the anterior and lower part of the body of the os sphenoidale, towards the spina nasalis anterior. In aged specimens this line of union is obliterated.

The borders of the **lamina perpendicularis** of the os ethmoidale are five in number: (1) the *upper border* is defined by the lamina cribrosa, and is horizontal; (2) the *anterior superior border* is directed downwards and forwards and articulates with the **spina frontalis**, a slender process of the os frontale which intervenes between the lamina perpendicularis and the crest formed by the union of the ossa nasalia; (3) the *posterior border* is vertical and united to a median crest, the **crista sphenoidalis**, on the corpus ossis sphenoidalis; (4) the *lower posterior border* is united, along the line already noted, with the upper and anterior edge of the vomer; (5) the *lower* *anterior border* is free, but in the living subject it is continuous with the septal cartilage of the nose.

It will be seen in the section that the **lamina perpendicularis** is continued upwards into the cranial cavity to form the **crista galli**, and that just below the plane of the lamina cribrosa it exhibits a series of faintly marked nearly

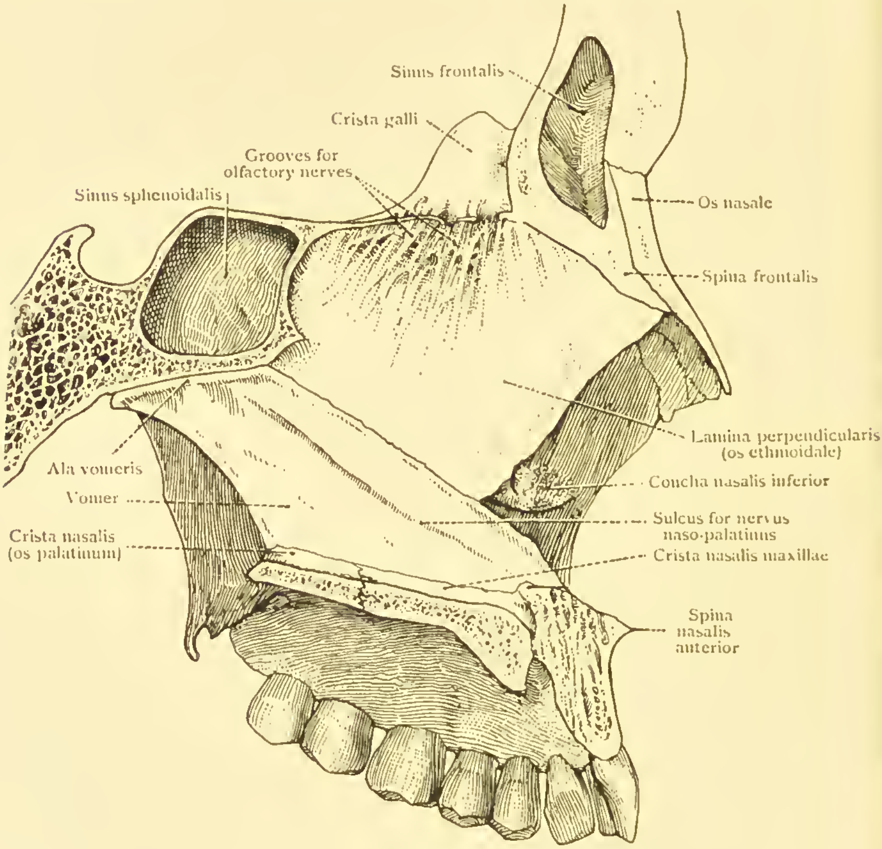

FIG. 133.—The osseous nasal septum.

vertical grooves, in which lie the olfactory nerves of the septum nasi.

The **vomer**, forming the lower and posterior part of the septum, has an irregular quadrilateral outline. Its *posterior border*, which is free, is directed downwards and forwards, and lies, as we have already seen, between the choanae, or posterior nares. Its *lower border* is nearly horizontal, and is united to the median crest, the **crista nasalis**, formed by the union of the partes horizontales of the ossa palatina and the processus palatini of the maxillae. The *upper border* of the vomer is cleft to receive a vertical median ridge, the **rostrum sphenoidale**, which springs from the under aspect of the corpus ossis sphenoidalis. The diverging edges of this cleft, known as the **alae vomeris**, turn outwards below the body of the os sphenoidale, where each meets, as we have seen, the processus vaginalis of the internal pterygoid plate. The *anterior border* is the longest, and in its upper part joins the lamina perpendicularis of the os ethmoidale. Its lower part is grooved to receive the septal cartilage, and a long slender process of the cartilage is often continued backwards

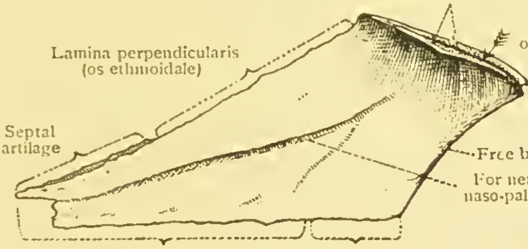

FIG. 134.—The vomer from the left side.

and upwards for a variable distance between the vomer and the ethmoid.

In most cases the surface of the vomer is marked by a narrow sulcus, which is directed downwards and forwards towards the upper end of the foramen incisivum, and indicates the course of the nervus naso-palatinus.

We have already noticed that the lower part of the anterior border of the vomer, and the lower anterior border of the lamina perpendicularis ossis ethmoidalis, can be seen in the entire skull by looking into the apertura piriformis.

Both the **crista sphenoidalis** and the **rostrum sphenoidale** assist, to a slight extent, in forming the upper and posterior part of the septum ; while the **crista nasalis** formed by the **ossa palatina** and **maxillae** completes the lowest part. The upper and anterior part is completed by the **spina frontalis** and the crest formed by the union of the **ossa nasalia**. All these, however, take but a small part in the formation of the septum in comparison with the vomer and the lamina perpendicularis of the os ethmoidale.

It will be noticed that the septum nasi ossium in the adult is rarely vertical and median, but is usually bent to one or other side, in its lower and anterior part.

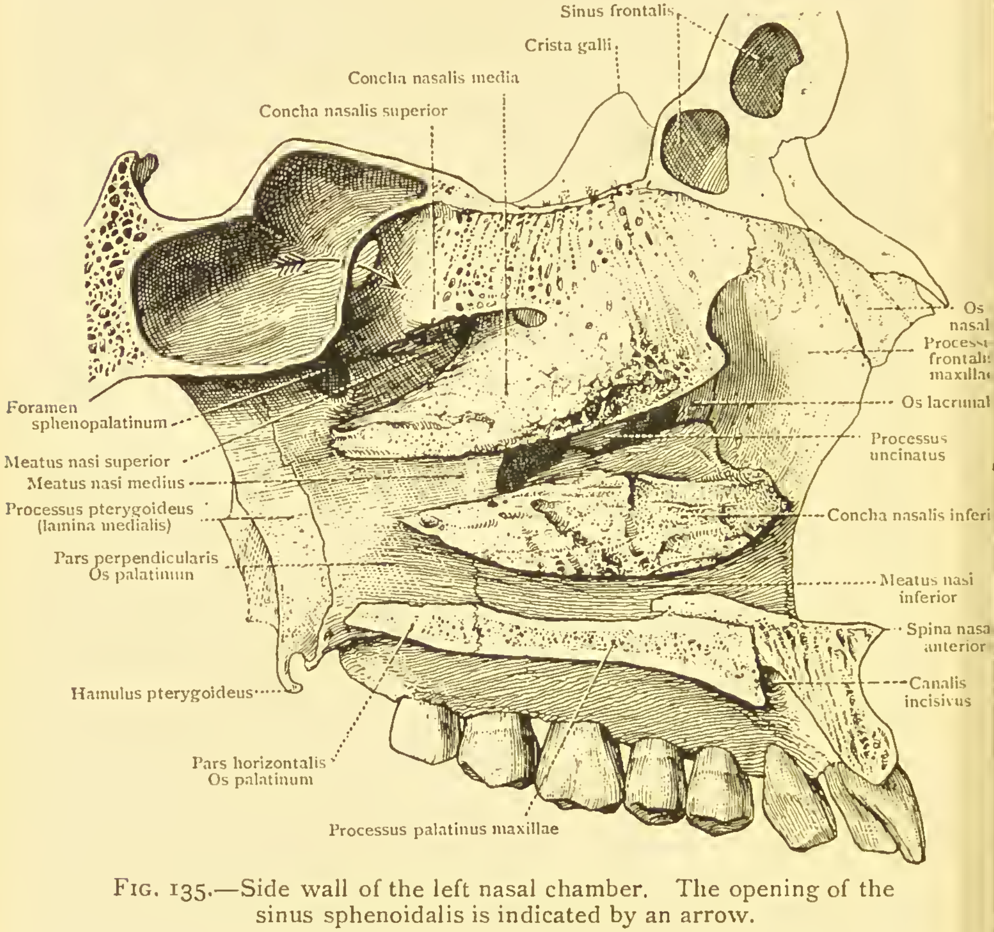

FIG. 135.—Side wall of the left nasal chamber. The opening of the sinus sphenoidalis is indicated by an arrow.

THE SIDE WALL OF THE NASAL CHAMBER.

The side wall of the nasal chamber should now be examined. It is formed by a number of different bones, and over the greater part of its surface it is very irregular. The anterior and upper part is smooth, and is formed by the deep aspect of the **os nasale** and of the **processus frontalis** of the **maxilla**. Further back is a region in which the three **conchae**, or *turbinated bones*, project into the nasal chamber; behind these the lateral wall is formed by the **lamina medialis**

processus pterygoidei, and by the **pars perpendicularis** of the **os palatinum**.

Each concha is a delicate curved plate of bone, with an upper attached edge and a lower free border. Its lower surface is concave, and overhangs one of the meatuses of the nose. Thus we find under shelter of the **concha inferior**, the **meatus nasi inferior**; beneath the **concha media**, the **meatus nasi medius**; and below the **concha superior**, the **meatus nasi superior**. It should be explained that the concha superior and the concha media are parts of the os ethmoidale, and that the concha inferior is a separate bone,

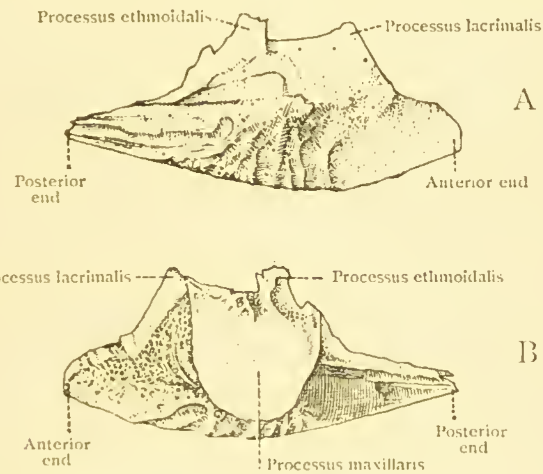

Fig. 136.—Left concha nasalis inferior; A, from the inner, and B, from the outer aspect.

and only becomes fused to the side wall of the nasal chamber after adult age is reached.

The **meatus nasi inferior** is longer than either the superior or middle meatus. It is also more spacious, in correspondence with the greater width of the nasal chamber in its lowest part. Its *floor* is formed by the hard palate, and lies horizontally from before backwards, and is concave from side to side. In its *outer wall* lie the maxilla and the os palatinum, and from it springs the concha inferior, which arches over the meatus inferior and forms its *roof*. The opening of the **canalis naso-lacrimalis**, or *nasal duct*, will be found at the junction of the roof and outer wall near the anterior end of the meatus. The origin of this canal at the anterior part of the inner wall of the orbit has already been noticed (pages 191 and 205).

The **concha nasalis inferior**, or *inferior turbinated bone*, has a convex inner and upper, and a concave lower and outer surface, both of which are very uneven. These surfaces meet along the lower free border of the bone, which lies approximately horizontal. The anterior end of the bone reaches almost to the edge of the apertura piriformis, and is larger and less pointed than the posterior extremity, which lies vertically over the posterior border of the hard palate. The upper attached border of the concha inferior articulates with the pars perpendicularis of the os palatinum and with the inner aspect of the maxilla. From this border of the bone, two little processes pass upwards, the more anterior, named **processus lacrimalis**, articulating with a part of the os lacrimale; the more posterior, the **processus ethmoidalis**, joining a slender descending process of the os ethmoidale known as the **processus uncinatus.** A flat scale-like process projects downwards from the upper border of the concha inferior, and helps to close the large irregular opening, or hiatus, of the sinus maxillaris. This process, known as the **processus maxillaris**, is best seen in the isolated concha nasalis inferior (see fig. 136).

The **concha superior** and **media**, sometimes called the *ethmoidal conchae* or *ethmo-turbinals*, have pitted uneven surfaces, like those of the concha nasalis inferior. The **meatus nasi medius** lies between the middle and inferior conchae, and is narrower than the meatus inferior. The **concha nasalis media**, which forms its roof, extends backwards to a point vertically over the posterior edge of the hard palate, and its posterior extremity lies near the **foramen spheno-palatinum**, which leads from the nasal chamber into the fossa pterygo-palatina. As the lower free edge of the concha media is traced forwards, it at first runs a nearly horizontal course, but, towards its anterior end, changing its direction, it turns suddenly almost vertically upwards, and ends by joining the lateral wall of the nasal chamber close to the anterior part of the roof.

In the outer wall of the meatus medius may be seen the lower end of the os lacrimale, the processus uncinatus of the os ethmoidale, and a portion of the pars perpendicularis of the os palatinum. This wall is often very incomplete in the macerated skull, and large irregular openings may be present, leading into the sinus maxillaris. High up, under shelter of the concha media, there lies a deep sulcus directed downwards and backwards, and known as the **hiatus semilunaris infundibuli.** It is bounded above and behind by a prominence, named the **bulla ethmoidalis**, which somewhat resembles a turbinated bone. In front and below, it is defined by the sharp posterior edge of the processus uncinatus. The hiatus semilunaris and the bulla ethmoidalis can only be seen after the removal of the concha media. The hiatus is continued forwards and upwards into a narrow space, the **infundibulum ethmoidale**, which

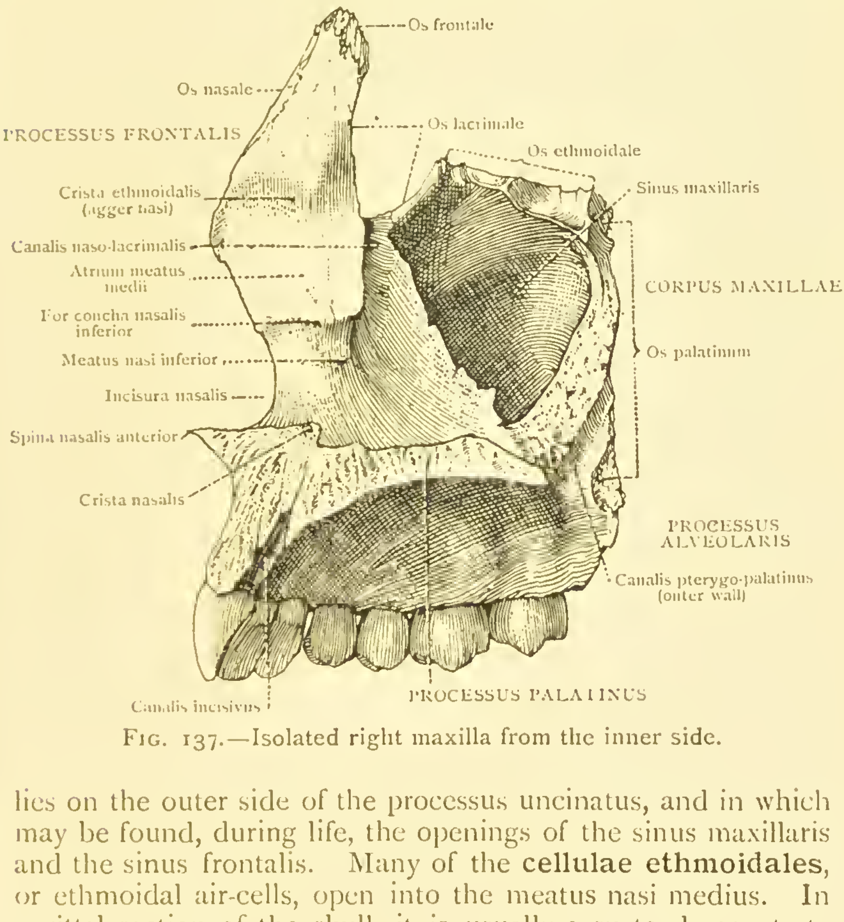

FIG. 137.—Isolated right maxilla from the inner side.

lies on the outer side of the processus uncinatus, and in which may be found, during life, the openings of the sinus maxillaris and the sinus frontalis. Many of the **cellulae ethmoidales**, or ethmoidal air-cells, open into the meatus nasi medius. In sagittal section of the skull, it is usually easy to demonstrate the connexion of the sinus frontalis with the meatus nasi medius.

The **meatus superior** is a narrow curved recess below the level of the concha superior and above the concha media. It lies almost entirely above the level of the opening of the choana, or posterior naris, and its long axis is directed downwards and backwards. It does not extend nearly so far forwards as the meatus inferior or the meatus medius, and its walls are formed entirely by the os ethmoidale. Into this meatus open some of the ethmoidal air-cells.

The extreme upper and posterior part of the nasal chamber, which lies above and behind the concha superior, and in front of and below the corpus ossis sphenoidalis, is known as the **recessus spheno-ethmoidalis.** In its posterior wall will be seen the large aperture of the sinus sphenoidalis.

Above the anterior end of the concha inferior the side wall of the nasal chamber is formed by a smooth shallow depression on the processus frontalis maxillae which is continued posteriorly into the outer wall of the meatus medius. This part of the nasal chamber is therefore known as the **atrium meatus medii.** Its upper limit is formed by a slight elevation or ridge, called the **crista ethmoidalis** or *agger nasi.* Before completing the study of the anterior part of the lateral wall of the nasal chamber, the student should identify the groove on the inner, or posterior aspect of the os nasale, for the terminal branch of the nervus naso-ciliaris or nasal nerve.

The part of the nasal chamber which lies behind the conchae and whose wall is formed, as we have seen, by the pars perpendicularis of the os palatinum and by the lamina medialis of the processus pterygoideus is known as the **meatus naso-pharyngeus.**

THE ROOF OF THE NASAL CHAMBER.

The *roof* of the nasal chamber consists of (1) an anterior part which slopes downwards and forwards, formed by the os nasalis and the spina nasalis of the os frontale, (2) an intermediate horizontal portion formed by the lamina cribrosa of the os ethmoidale, and (3) a posterior part which slopes downwards and backwards and is formed by the body of the os sphenoidale. It will be noticed that the roof, especially in its intermediate part, is extremely narrow from side to side.

The posterior sloping part of the roof is wider from side to side than the horizontal portion, and on it is the large opening of the sinus sphenoidalis. In some skulls this opening may be seen on looking in through the apertura piriformis, but in many cases the concha media completely blocks the view of the posterior part of the roof of the nasal chamber. It is well, therefore, that the opening should be examined in the isolated os sphenoidale (fig. 124).

THE FLOOR OF THE NASAL CHAMBER.

The *floor* of the nose lies horizontally from before backwards, and is smooth and concave from side to side. It is formed by the upper surface of the processus palatinus maxillae and by the upper aspect of the pars horizontalis of the os palatinum.

OS ETHMOIDALE.

Having completed his study of the nasal chamber the student is advised to examine an isolated **os ethmoidale.** He should first identify the thin lamina perpendicularis and

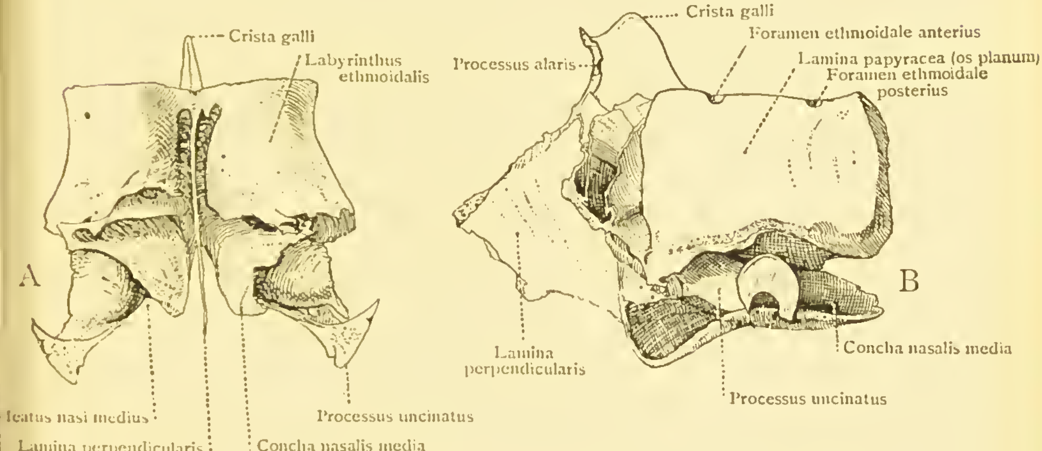

FIG. 138.—Os ethmoidale; A, from behind, and B, from the left side.

the **crista galli** which forms its continuation upward into the cranial cavity. The extreme narrowness of the middle portion of the roof of the nasal fossa should be noticed, and the **lamina cribrosa**, which forms it, should be looked at from below against the light.

The smooth **lamina papyracea**, or *os planum*, which forms the inner wall of the orbit is easily identified, and in front of it will be seen some air-cells which are completed in the entire skull by the os lacrimale and processus frontalis of the maxilla. From this region springs the slender descending **processus uncinatus**, which passes downwards and backwards to assist in closing the hiatus of the sinus maxillaris, articulating at its distal end with the concha nasalis inferior. The end of this process we have already seen in the outer wall of the meatus nasi medius. No difficulty will be experienced in identifying the **concha superior** and **media** if the os ethmoidale is viewed from behind. The position of the **foramina ethmoidalia**, leading into the orbit, and of the **foramen caecum**, which opens in front of the crista galli, into the fossa cranii anterior, should be noticed.

The student will appreciate the delicacy of the plates of bone which form the **labyrinthus ethmoidalis**, or *lateral mass* of the os ethmoidale, and enclose the air-cells, or **cellulae ethmoidales**, of the os ethmoidale. These air-cells intervene between the orbit and the nasal chamber, and most of them open, as we have seen, into the meatus nasi medius

THE TEETH.

There are a number of important points connected with the form and arrangement of the teeth which should be noticed before the study of the skull is completed.

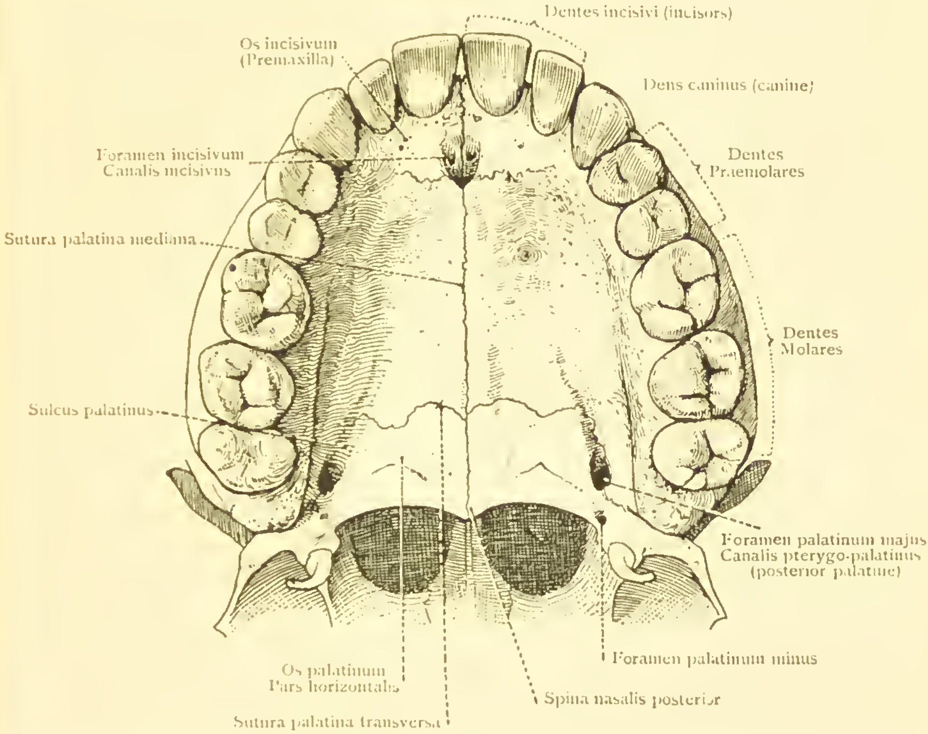

FIG. 139.—Hard palate and arcus dentalis superior. From an adult subject.

It is well, in the first instance, to examine an adult specimen in which the teeth are well preserved, and then to study the form and arrangement of the teeth in the skull of a child of about three or four years of age.

DENTES PERMANENTES.

The adult, or *permanent teeth*, **dentes permanentes**, are thirty-two in number; sixteen of these are fixed in the alveolar arch of the mandible and form the **arcus dentalis inferior**;

and sixteen are fixed in the processus alveolares of the maxillae and form the **arcus dentalis superior**. On each side of the middle line, and in both the upper and lower jaws, the teeth are classified as follows: two incisors, one canine, two praemolars or bicuspids, and three molars. No difficulty will be experienced in distinguishing these groups from one another as the teeth lie in the jaws.

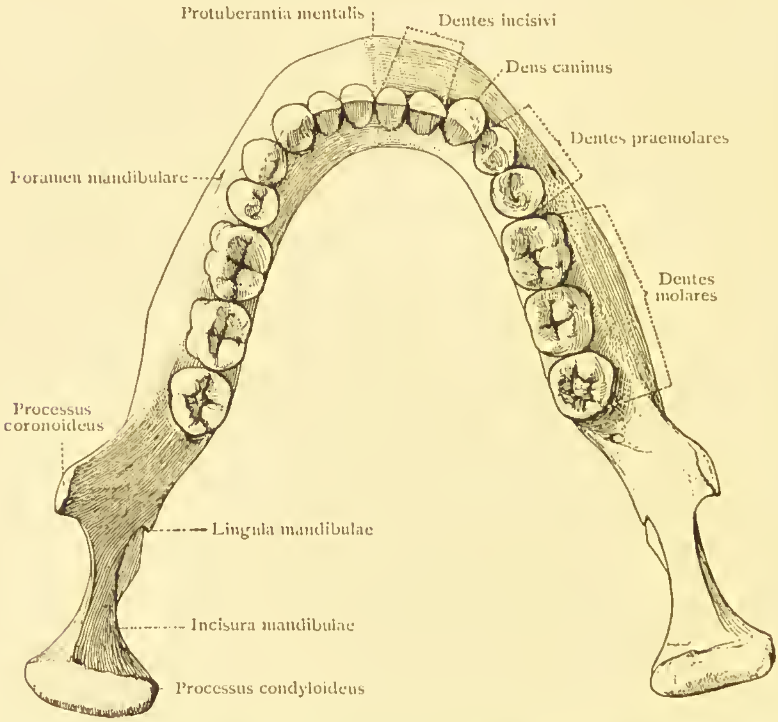

FIG. 140.—The mandibula from above, showing arcus dentalis inferior. From an adult subject.

The exposed portion of each tooth is covered by a layer of hard white *enamel*, or **substantia adamantina**, and is known as the *crown*, or **corona dentis**. The shape of the crown varies in the different teeth: in the incisors it has a cutting edge; in the canine it is conical, or pointed; in the praemolars it has two cusps, or tubercles; and in the molars it is of large size and is marked by grooves, separating four or five little tubercles. The crown is connected with the *root*, or roots, by a slightly constricted portion known as the *neck*, or **collum dentis**. At the neck the enamel exhibits a thin free edge, for it is not continued beyond the crown. Some of the teeth, such as the incisors and canines, have a single root, or **radix**; others, like the molars, possess two or more **radices**. At the apex of each root is a minute opening, the **foramen apicis dentis**, through which the vessels and nerves of the teeth enter a little canal called the *root canal*, or **canalis radicis dentis**, leading into the **cavum dentis**, or *pulp cavity*, which during life is filled by the soft *tooth pulp*, or **pulpa dentis**. The student should examine a number of isolated teeth and familiarize himself with the points just mentioned. The arrangement of the canals and the form of the pulp cavity can be readily studied by sawing teeth in section, and it will be found that the shape of the cavity and the plan of the root canal, or canals, vary in the different groups of teeth. By far the

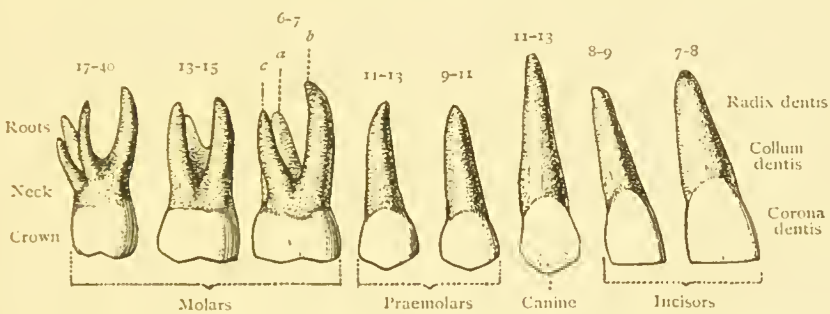

FIG. 141.—Permanent teeth from arcus dentalis superior of right side. Viewed from the buccal aspect. The numerals indicate the dates of eruption. *a*, palatine; *b* and *c*, buccal roots of first molar. The third molar exhibits four roots.

greater part of the tooth is composed of a substance known as *dentine* (**substantia eburnia**). In the crown of the tooth the dentine is covered by the thin dense layer of enamel, and where it forms the root by a very thin layer of bone, called *cementum*, *crusta petrosa* or **substantia ossea**.

Dentes Incisivi.—The *incisor teeth* are easily identified by the chisel, or wedge-shaped form of their crowns. The *labial* or anterior *surface* of each is slightly convex in all directions; the *lingual surface* slightly concave.

The upper incisors are larger than the lower, and the upper central is the largest of all. The cutting edge of the upper incisors slopes away towards the lateral surface of the crown, and the difference in the angle formed by the cutting edge and the inner and outer margins of the crown makes it possible to identify the side to which isolated specimens of these teeth belong.

The lower incisors are distinguished by their small size. The cutting edge of the lower central is practically at right angles to the long axis of the tooth, but that of the lower lateral incisor usually slopes slightly towards the outer edge of the crown.

All the incisor teeth have single tapering roots, slightly flattened and grooved longitudinally on each side. The flattening and grooving is more marked in the case of the lower incisors.

Dentes Canini.—The *canine teeth* may be recognized by their pointed crowns. The summit of the crown lies nearer to the mesial than to the lateral border of the canine tooth, and hence the cutting edge has a longer slope towards the

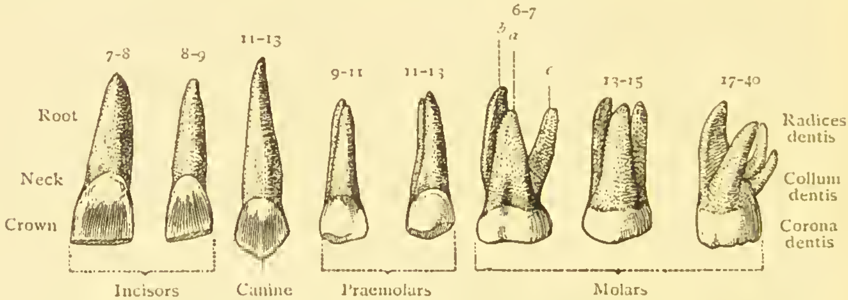

FIG. 142.—Permanent teeth from arcus dentalis superior of right side. Viewed from the lingual aspect. The numerals indicate the dates of eruption. *a*, palatine; *b* and *c*, buccal roots of first molar. The third molar exhibits four roots.

outer than towards the inner side. The *labial surface* of the crown is convex; the *lingual* concave. The upper canine, sometimes called the 'eye tooth' is larger than the lower, and when the jaws are closed its pointed crown lies behind that of the lower canine.

Dentes Praemolares.—The *praemolar teeth* are also known as the *bicuspids*. Looked at from the labial, or buccal aspect they resemble the canine teeth, but when the grinding, or masticatory, surface is examined it will be seen to present two cusps. In the upper praemolars the *lingual cusp* is well developed and separated from the *buccal cusp* by a deep sulcus. In the lower praemolars, especially in the first, the lingual cusp is less prominent. The lingual cusp in the praemolars might be regarded as a great development of the minute cusp often present on the lingual aspect of the canine teeth, and usually best marked in the upper. This latter is developed from a slight ridge, known as the *cingulum*, which lies in the upper incisors and canines, at the edge of the lingual aspect of the crown. The roots of the praemolar teeth are usually single, but in the upper jaw the first praemolar frequently has its root divided into lingual and buccal prongs.

Dentes Molares.—The *molar teeth* are recognized by their large crowns, and by the grooves and cusps which mark their grinding surfaces. In each jaw the first is the largest, and the third the smallest molar tooth.

In the *upper molars* the number of cusps may vary slightly, but usually four are present:—namely, two *lingual* and two *buccal*. The crown of the first upper molar, however, has frequently a minute fifth cusp which lies at the anterior part

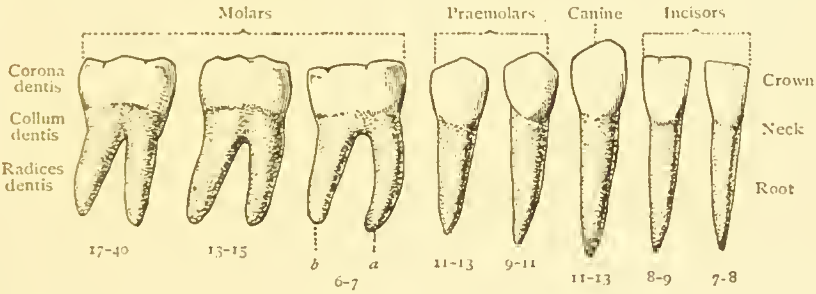

FIG. 143.—Permanent teeth from arcus dentalis inferior of right side. Viewed from the buccal aspect. The numerals indicate the dates of eruption. *a*, anterior; *b*, posterior root of first molar.

of its lingual edge. The grinding surface of this tooth has a characteristically rhomboidal outline, and it will be noticed that the posterior buccal and the anterior lingual cusps are connected by an oblique, slightly raised ridge. The position of the cusps gives the intervening sulcus a somewhat H-shaped form. The second upper molar resembles the first, but the markings just mentioned are less distinct; in the third upper molar variations and irregularities in the markings of the crown are very common.

The first and second upper molars have each three roots:—an anterior and a posterior *buccal*, and a *palatine*. The roots of the third upper molar are very variable in number and disposition, very commonly they are partly fused together.

The *lower molars* resemble those in the upper jaw but each has only two roots. The crown of the first lower molar exhibits five cusps, three of which are at the buccal, and two at the lingual edge. The second lower molar has four cusps separated from one another by a well-marked crucial sulcus. The third lower molar has a very variable crown which sometimes exhibits five, sometimes four cusps.

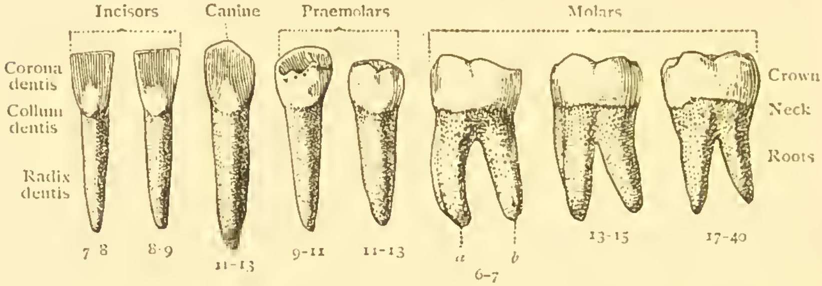

FIG. 144.—Teeth from arcus dentalis inferior of right side. Viewed from the lingual aspect. The numerals indicate the dates of eruption. *a*, anterior ; *b*, posterior root of first molar.

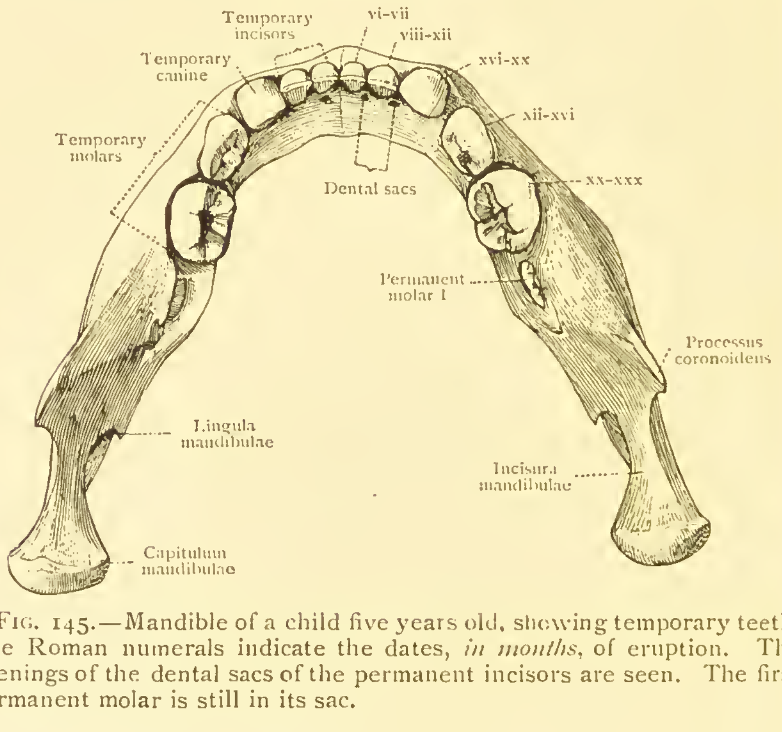

FIG. 145.—Mandible of a child five years old, showing temporary teeth. The Roman numerals indicate the dates, *in months*, of eruption. The openings of the dental sacs of the permanent incisors are seen. The first permanent molar is still in its sac.

The roots of the lower molars, which as we have noted, are two in number, are flattened from before backwards and curved in a backward direction. They lie one in front of the other, and are named *anterior* and *posterior*.

DENTES DECIDUI.

The *temporary*, *milk*, or *deciduous teeth*, **dentes decidui**, should be examined in the skull of a child of about three to five years of age. They are twenty in number, and on each side of the upper and lower jaws we find two incisors, one canine and two temporary molars.

The temporary are distinguished from the permanent teeth by their smaller size, by their whiter enamel, and by the fact

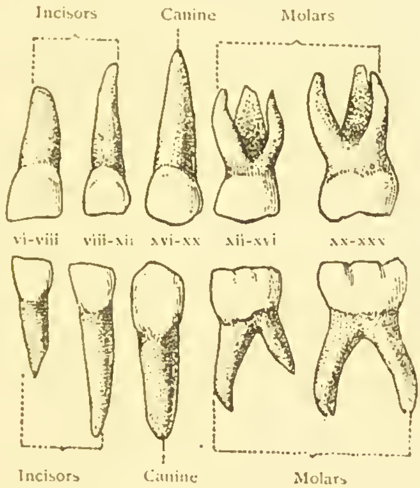

FIG. 146.—Temporary teeth, viewed from the buccal aspect. The Roman numerals indicate the dates of eruption *in months.*

that the enamel ends abruptly at the neck and so forms a ridge at its junction with the cementum. The roots of the temporary teeth are relatively longer and more slender than those of the permanent set. Except for the differences noted, the temporary incisors and canines resemble those of the permanent dentition. The second temporary molar resembles the first permanent molar, but the first temporary molar is unlike all the other teeth. The crown of the upper first temporary molar exhibits three cusps, two on the buccal and one on the lingual margin; the buccal being considerably larger than the lingual cusps. The crown of the lower first temporary molar has four cusps, two lingual and two buccal.

The roots of the temporary molars diverge widely, and enclose the crowns of the permanent bicuspids which take their place when they are shed.

Eruption of the Temporary Teeth.

There is much variation in the times at which the *temporary teeth* erupt, but it may be mentioned that those in the lower jaw erupt a little earlier than those in the upper. The central incisors are the first to appear and usually erupt from the fifth to the eighth month; the second molars are the last, and appear when the child is a year and a half to two years old.

The following table gives the average dates of eruption of the temporary teeth :—

central incisors . .	vi	to	viii	months
lateral incisor . .	viii	,,	xii	,,
canine . . .	xvi	,,	xx	,,
first temporary molar .	xii	,,	xvi	,,
second temporary molar	xx	,,	xxx	,,

Eruption of the Permanent Teeth.

Of the *permanent dentition* the first molar is the first tooth to erupt; it appears sometime between the age of six and seven years. The second molar erupts at the thirteenth to the fifteenth year, and the third molar, or 'wisdom tooth' at very irregular dates from the seventeenth to the fortieth year.

The permanent replace the temporary central incisors about the seventh or eighth year; the permanent lateral incisors the temporary laterals about the eighth or ninth year. The permanent canine replaces the temporary canine between the eleventh and thirteenth year.

The first praemolar replaces the first temporary molar in the ninth to the eleventh year, and the second praemolar, the second temporary molar in the eleventh to the thirteenth year.

The following table gives the approximate years in which the permanent teeth appear :—

central incisor .	7	to	8	years
lateral . . .	8	,,	9	,,
canine . . .	11	,,	13	,,
first praemolar .	9	,,	11	,,
second praemolar .	11	,,	13	,,
first molar . .	6	,,	7	,,
second molar .	13	,,	15	,,
third molar . .	17	,,	40	,,

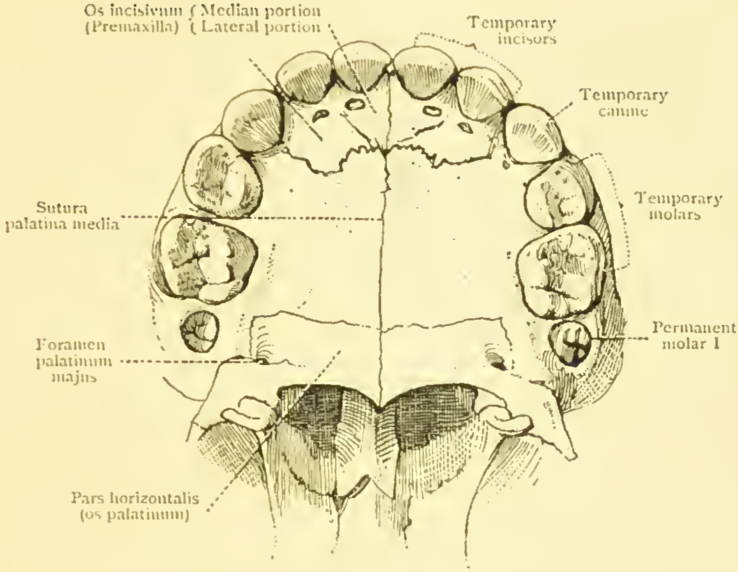

FIG. 147.—Hard palate and temporary teeth of a child five years old. The dental sacs of the permanent incisors are well seen ; the first permanent molar is not yet erupted. Note the subdivision of the os incisivum into median and lateral portions.

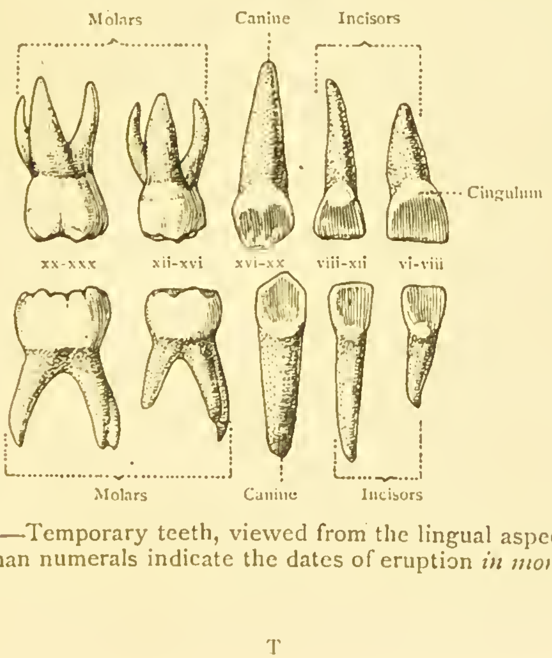

FIG. 148.—Temporary teeth, viewed from the lingual aspect. The Roman numerals indicate the dates of eruption *in months*.

THE OS HYOIDEUM.

The **os hyoideum,** or hyoid bone, is a small slender bone which lies below the mandibula and above the larynx. It has a U-shaped outline and may be readily felt in the upper part of the neck of the living subject. It is often composed of five separate pieces which may, or may not, become fused in the adult. In the middle line we find the **corpus ossis hyoidei,** or body, which is compressed from before backwards. Attached to it on each side there is a cornu minus and a cornu majus. The **cornu majus** projects horizontally backwards ; the much smaller, and very variable, **cornu minus** is directed backwards and upwards from the upper and outer part of the body, close to its junction with the cornu majus. The stylo-hyoid

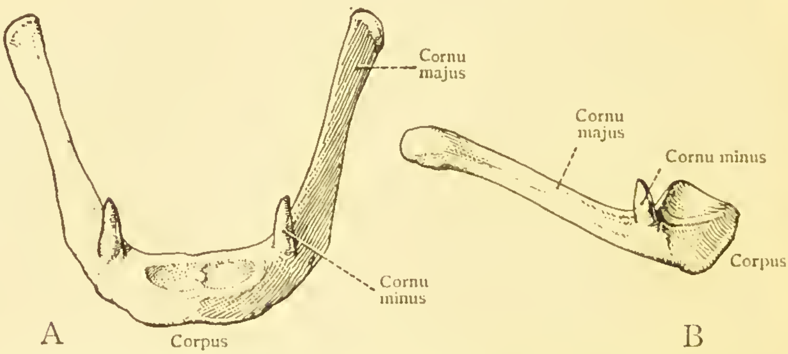

FIG. 149.—Os hyoideum ; A, from above, and B, from the left side.

ligament connects the cornu minus with the tip of the processus styloideus of the os temporale.

The os hyoideum gives attachment to a large number of muscles some of which pass to the tongue, and to the mandible ; others, such as the sterno-hyoid and omo-hyoid, reach the os hyoideum from below. The muscular wall of the pharynx also has an attachment to the os hyoideum.

Like the processus styloideus with which it is connected, the os hyoideum has its origin from the cartilages which appear in the upper gill arches of the embryo. It is from developmental considerations, that the description of os hyoideum is included in the account of the skull.

The bone begins to ossify just before birth.

COMPOSITION OF BONE.

Each bone is composed of an organic matrix impregnated with inorganic salts. Roughly speaking the organic matter forms about one-third, and the inorganic matter two-thirds of the weight of the bone. Two simple experiments can be made to illustrate in a striking manner some important facts regarding the composition of bone.

(1) If a bone be heated to a high temperature it first becomes black, and then white in colour, as the organic matter is first charred, and afterwards driven off. The resulting 'bone' is extremely brittle, but if the burning has been carefully carried out, the 'bone' retains its shape and size, and it will be found at the end of the experiment to have lost about one-third of its weight.

(2) If a bone be placed in dilute hydrochloric acid for some days, the earthy salts dissolve, and the organic matrix is left behind. This will be found to have the exact shape of the bone and to show all the original markings in the most minute detail. If it is removed from the fluid the 'bone' can be readily crumpled up and bent in any direction, and yet it will resume its normal form when pressure is removed.

These observations lead us to recognize that bone owes its toughness and elasticity to its organic matter, and its hardness to the inorganic salts. The great strength and rigidity of the bone results from the combination of the organic and inorganic matter. That normal bone possesses considerable elasticity may be easily demonstrated by letting a rib fall from a height upon one of its ends and observing the manner in which it rebounds. It is interesting to note that in certain forms of disease, as in the condition known as rickets, in which the inorganic salts are deficient in amount, the bones lose their rigidity and those which support the weight of the body are unequal to the strain and become bent.

Of the inorganic salts, calcium phosphate is present in far the greatest quantity, representing more than half, indeed nearly 60 per cent., of the entire weight of the bone. Calcium carbonate is the only other salt present in considerable quantity, and forms nearly 8 per cent. of the entire weight. Calcium fluoride is present in very small amount, but probably adds much to the hardness of the bone.

It is a well-known fact that by continued boiling the organic matter of bone can be removed in the form of gelatine.

SHAPE AND STRUCTURE OF BONES.

It is obvious that the bones which compose the skeleton vary enormously in shape and size, yet they may be roughly arranged in three main groups, namely:—(1) long bones, (2) short bones, and (3) flat bones. No sharp line separates the members of these groups, and some bones cannot satisfactorily be placed in any of them, nevertheless for many purposes the classification is useful.

Ossa Longa. The long bones include the bones of the thigh, leg, upper arm, forearm, the ossa metacarpalia, the ossa metatarsalia, and the phalanges of the fingers and toes. The ribs and clavicles are also included, although in some ways they differ from the more typical long bones.

Ossa Brevia. The short bones are represented by the ossa carpalia and the ossa tarsalia, and also by the ossa sesamoidea which occur in connexion with certain tendons of the upper and lower limbs. The vertebrae are often included among the short bones, although their symmetrical shape and extremely irregular outline might readily lead to the formation of a separate class for their reception. If such a class were formed it might suitably include the bones of the base of the cranium.

Ossa Plana. The flat bones include many of the bones forming the cranium and the face, and also the scapula and the os coxae.

The student should study the structure and the mode of development of typical bones, belonging to each of the above groups, and he will probably find it best to begin with one of the larger long bones, such as the femur, or humerus.

STRUCTURE OF A LONG BONE.

If one of the long bones be divided in a longitudinal direction it will be found that the shaft has the form of a tube with a dense hard wall. The contained cavity is known as the **cavum medullare**, or *medullary cavity*, and during life is filled with *yellow marrow*, or **medulla ossium flava**. A careful examination will show that the hard dense bone of the shaft is pierced by a minute canal, the **canalis nutricius**, through which a little artery enters to supply the marrow. The opening of this canal is known as the **foramen nutricium**, and its position for each long bone is fairly constant. In some cases more than one such nutrient foramen and canal is normally present. It is interesting to observe that the canal pierces the bone obliquely, and that its direction is always the

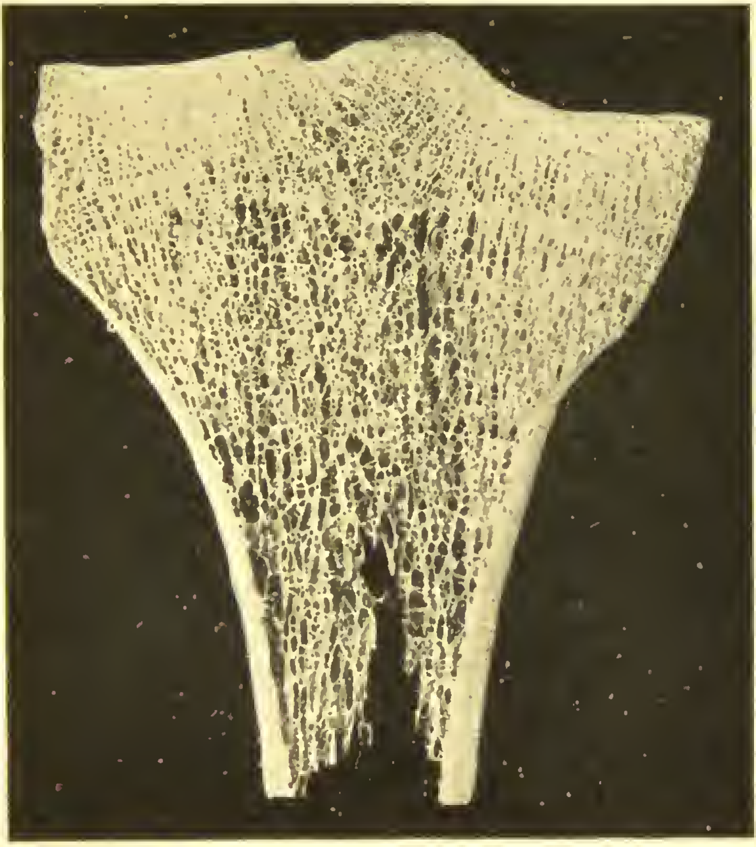

FIG. 150.—Thin sawn section of the upper end of the tibia. The arrangement of the lamellae forming the cancellous bone and its thin outer layer are well seen. In the lower part the dense compact bone forming the wall of the cavum medullare is apparent. Note the vertical direction of the main lamellae.

same in the corresponding long bones from different skeletons. We find that these canals in the long bones always run towards the end of the bone at which growth in length first ceases, i. e. towards the end where there is no epiphysis, or at which the epiphysis first unites with the shaft.

The section shows that towards each extremity of the long bone the cavum medullare becomes filled up with a sponge-like network of interlacing thin bars and plates, and that the dense wall becomes reduced to a thin shell of bone which covers over this spongy mass. The minute spaces, enclosed by the bony fibres and lamellae, are filled during life by *red marrow*, the **medulla ossium rubra**.

The dense bone of the shaft is spoken of as **substantia compacta**, or *compact bone*; the spongy mass which forms the extremities is called **substantia spongiosa**, *cancellous*, or *spongy bone*; the thin covering layer is known as **substantia corticalis**.

The arrangement of the lamellae forming the substantia spongiosa is almost constant for each bone, as may be demonstrated by sawing fresh bones and washing out the marrow which fills up the spaces between the lamellae, or by the use of X-ray photographs. Usually the main lamellae lie in planes perpendicular to the articular surfaces, and are intersected at right angles by another series of bony plates. In addition many of the lamellae of the long bones form interlacing right and left-handed spirals, which intersect at right angles and materially add to the strength of the bone. It will be frequently found that the direction of the main lamellae coincides with the direction in which weight is transmitted, or in which muscular strain takes effect. In spite of their delicate structure, seen so well in section, the cancellous ends of the long bones will resist enormous pressure without collapsing, if such pressure is applied in the normal direction, i. e. the direction of the weight of the body, or of muscular strain (see figs. 150 and 151).

Lightness and strength are marked characteristics of the substantia spongiosa, the strength being very great in proportion to the weight of bone present. It must also be noted that the transmission of shock is greatly reduced by the presence of the masses of cancellous tissue to be found at the ends of the long bones and in other parts of the skeleton; the delicate interlacing lamellae and the spaces filled with red marrow take up, and do not readily transmit shock.

On each extremity of a long bone will be found a smooth area, or **facies articularis**, which glides during life on the corresponding area of an adjacent bone, when movement takes place between the two. Before the bone is macerated the facies articularis is covered by a thin layer of cartilage, the **cartilago articularis**, which has a wonderfully smooth surface, kept moist by the slight amount of fluid normally present in the joint cavity.

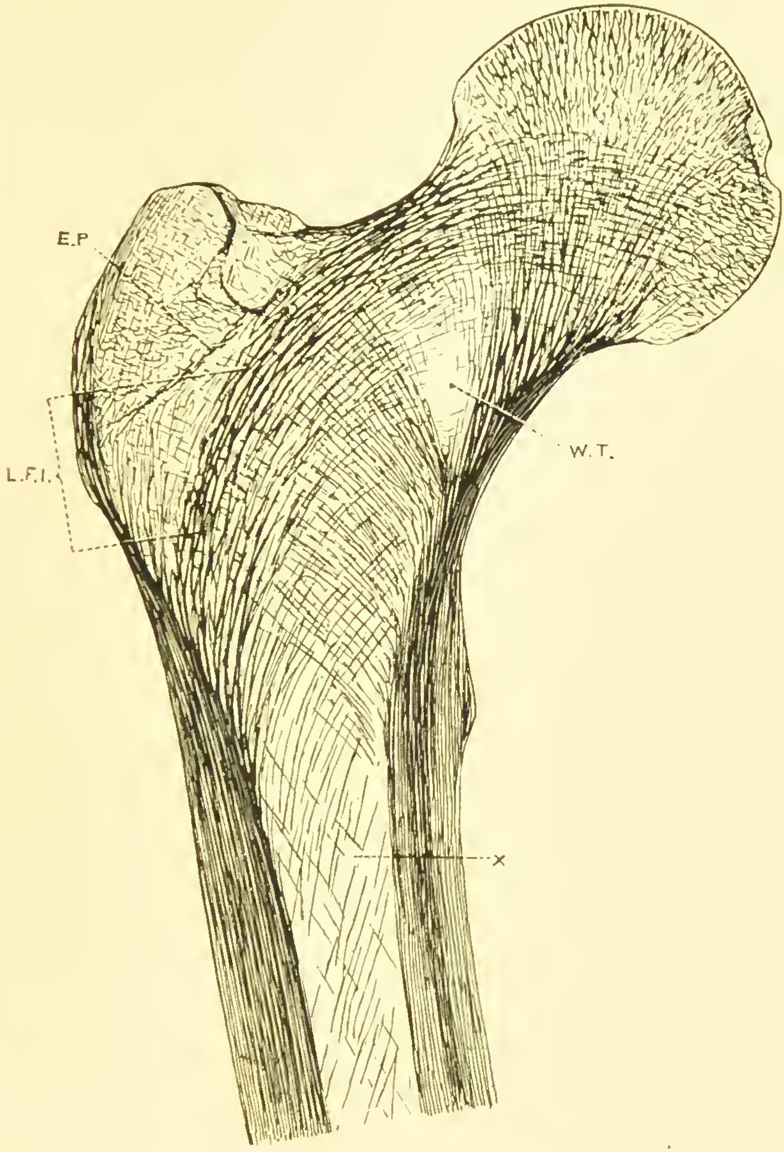

FIG. 151.—Drawing of an X-ray photograph of the upper part of the femur. Note the compact bone forming the shaft and enclosing the cavum medullare, X. At the upper extremity the cancellous bone is well displayed. LFI, dense lamellae in the cancellous bone, and WT, less dense region; EP, epiphyseal line for trochanter major. From a picture taken by W. S. Haughton, M.D.

DEVELOPMENT OF A LONG BONE.

In an early stage of its development each long bone is represented by a little mass of cartilage which has roughly the same shape as the future bone. Near the middle of this cartilage there appears a minute island of bone known as a 'centre of ossification', which rapidly spreads towards the extremities. At a much later date other little centres of ossification appear in the cartilage near the extremities.

The term **diaphysis** is applied to the part of the bone derived from the early formed, or *primary centre of ossification.* The parts ossified from the later formed, or *secondary centres*, are known as **epiphyses**. The epiphyses occur at the ends of a long bone; the diaphysis corresponds approximately to the shaft. The typical long bones possess epiphyses at both ends, but those which occur in the hand and foot have epiphyses at one end only.

The primary centres of ossification for the long bones begin to appear about the seventh week of intra-uterine development, at a time when the foetus is less than one inch in length. There is considerable variation among the different long bones in the dates at which they begin to ossify, but a good idea of the condition of the skeleton in the fourth month may be obtained from a study of fig. 152 which is a careful drawing of a human foetus, measuring three and a half inches. With one exception, namely the lower end of the femur, which begins to ossify just before birth, none of the ossific centres for the epiphyses of the long bones appear during intra-uterine life. All other epiphyses for the long bones only begin to ossify after birth, and although there is a wide range of variation in the times at which the centres appear in different bones, for each individual bone the dates are fairly constant. From what has been said it will be understood that until the epiphyses are ossified, the extremities of the long bones are represented by masses of cartilage, as may be well seen by examining the skeleton of a new-born child.

In most cases a single ossific centre appears in the cartilage which caps the extremity of a long bone, but in some bones two, or more, centres are formed. These multiple centres may fuse together and form a single epiphysis as in the upper end of the humerus; or in other cases, as at the upper end of the femur, two or three separate epiphyses are formed which unite independently with the shaft (see fig. 161).

The formation of the epiphyses of the long bones should be studied in the skeleton of an individual about fifteen or sixteen years of age. At this period all the epiphyses are well ossified;

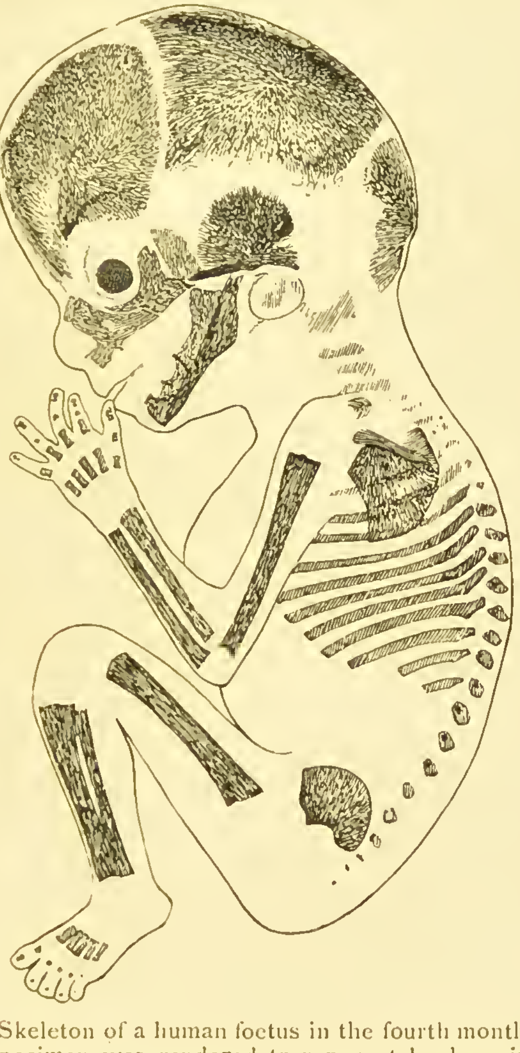

FIG. 152.—Skeleton of a human foetus in the fourth month of development. The specimen was rendered transparent by long immersion in a mixture containing glycerine and caustic potash. Slightly enlarged.

they have not yet fused with the diaphyses, and are only united to them by intervening plates of cartilage.

Growth in thickness takes place by the deposition of new layers of bone immediately beneath the **periosteum**, a membrane which during life closely invests, and is adherent to the bone surface. The periosteum is responsible for the vascular supply of the bone, as the small vessels contained in it give off branches which enter the extremely minute foramina to be seen on the surface of all bones when carefully examined. In this way the existence of the periosteum is not merely necessary for the growth of bone but is essential to its life. As a long bone increases in girth, the wall of the cavum medullare does not necessarily become thicker, since absorption of bone internally may take place *pari passu* with its deposition externally. It must further be mentioned, that the surface modelling of the living and growing bone is a function of the deep layers of the periosteum, which lay down new bone at unequal rates in different parts, and may remove it locally, thus shifting the positions of tubercles, ridges, or fossae, while the bone as a whole increases in size. It must always be borne in mind that bone, as a living tissue, depends for its nutrition and growth upon the activity of the periosteum.

In a long bone, growth in length takes place at the epiphyseal junction, and may be continued as long as the epiphysis is not consolidated with the diaphysis. When fusion of epiphysis and diaphysis takes place, all increase in length ceases. This most important fact should always be borne in mind in considering the growth of the individual in height and in length of limbs.

The student should carefully observe the lines of epiphyseal junction, and note in each case the amount of adult bone which is formed by the epiphysis. In this way he will be prepared to recognize the normal appearance of these parts as they may be presented in X-ray photographs of the living subject. Indeed, it is found that the X-rays afford valuable information regarding the exact outline of the epiphyses and their lines of junction in the different parts of the skeleton. It should also be remembered that occasionally, as a result of accident or muscular strain, separation of an epiphysis may occur, and lead to serious consequences; an accurate knowledge of the normal epiphyseal lines is needed in order to recognize this condition by an examination of the living parts, or of X-ray photographs.

We shall first study the epiphyses of the long bones of the upper, and then those of the lower extremity.

Humerus.—There is a *single epiphysis* for the *upper end* of the bone, which includes the caput humeri, the tuberculum majus, and tuberculum minus. The line of epiphyseal junction encircles the bone immediately below the level of the lowest part of the caput humeri; throughout the greater part of its course it lies horizontally, but on the posterior aspect of the bone the line usually takes an upward bend in the region between the caput humeri and the impression for the teres minor tendon. Specimens in which the epiphysis has become detached show that it is fitted as a cap over the upper pointed end of the diaphysis. The upper humeral epiphysis has usually *three centres* of ossification, one each for the caput, the tuberculum majus, and the tuberculum minus. These appear during

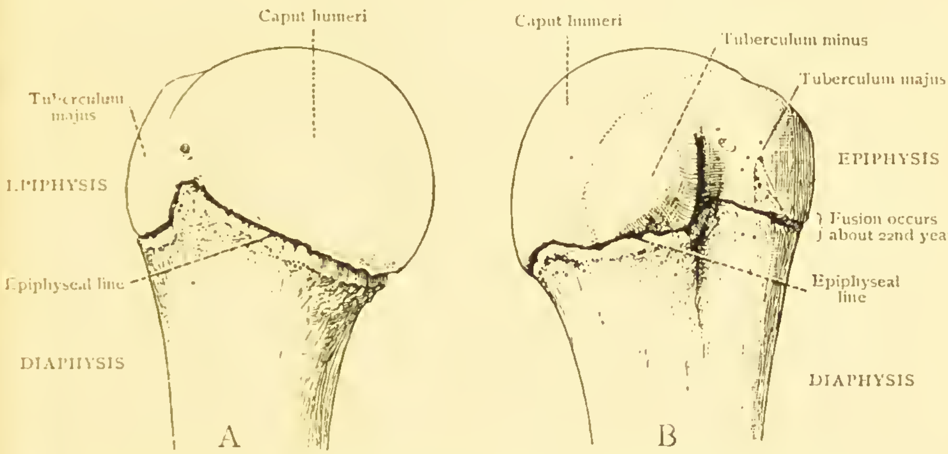

FIG. 153.—Upper end of the humerus. From a subject aged 17 years. A, from behind, and B, from in front, showing the single large epiphysis.

the first three years after birth, and fuse together in the sixth or seventh year. The epiphysis so formed joins the diaphysis about the twentieth to the twenty-fifth year.

There are *two epiphyses* for the *lower end* of the humerus; the larger of these includes the trochlea, the capitulum, and the epicondylus lateralis; the smaller corresponds to the epicondylus medialis. These epiphyses are separated by a small part of the diaphysis, which passes downwards between them. In front, the main line of epiphyseal junction runs along the upper edge of the trochlea and capitulum, outwards to reach the margo lateralis, at the upper part of the condylus lateralis. On the back of the humerus the line crosses the bone at the upper margin of the trochlea, and is so disposed that the sloping posterior aspect of the condylus lateralis lies below it. It is important to remember that the special epiphysis of the condylus medialis is sometimes detached as a result of muscular action.

Three centres of ossification appear for the *main lower epiphysis* during the third to the eleventh years. They early fuse together, and the epiphysis so formed unites with the diaphysis about the seventeenth year.

A *single centre* of ossification is formed, about the fifth year, for the *epiphysis of the epicondylus medialis*, which unites with the diaphysis about the eighteenth year.

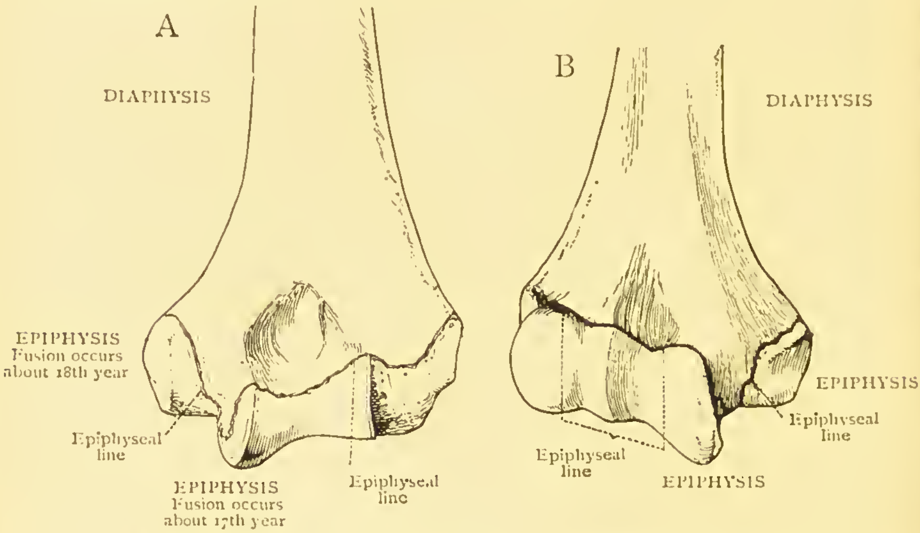

FIG. 154.—Lower end of the humerus. From a subject 17 years of age. A, from behind; B, from in front, showing the large and small epiphyses.

Ulna.—The epiphysis for the *upper end* of the ulna is remarkable in that it does not include the great articular areas of the bone. Usually a small scale-like epiphysis may be seen in the young ulna, forming the back and upper part of the olecranon. Occasionally, as in the specimen illustrated in fig. 155, the upper anterior portion of the olecranon is marked off by a narrow epiphyseal line, which crosses the upper part of the incisura semilunaris. The articular area for the radius, and by far the greater part of the articular surface for the humerus, lie below this line, and upon the diaphysis; the processus coronoideus and the greater part of the olecranon being formed as extensions of the diaphysis. The epiphysis begins to ossify about the tenth year, and may apparently have *one*, or *two centres*. The epiphysis joins the diaphysis about the seventeenth year.

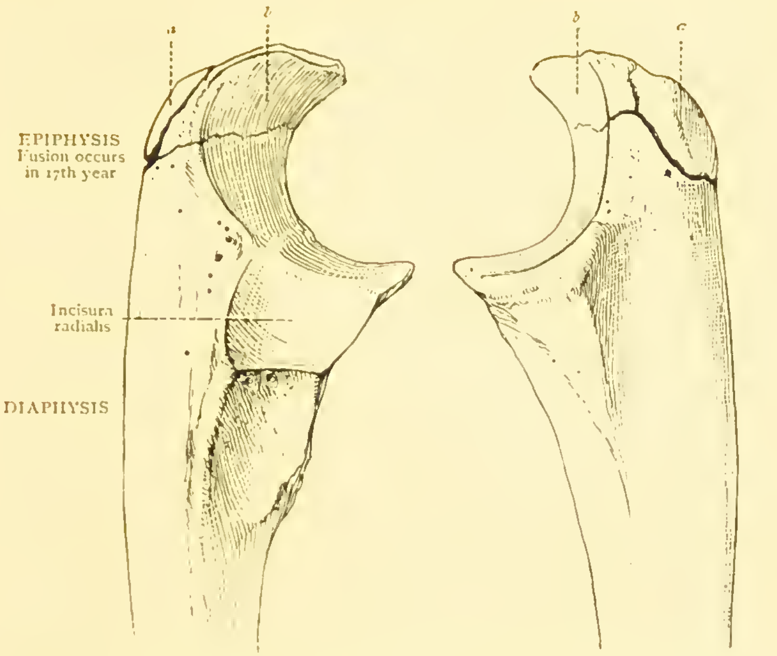

FIG. 155.—Upper end of the ulna. From a subject nearly 17 years old. *a*, the usual epiphysis; *b*, epiphysis occasionally present.

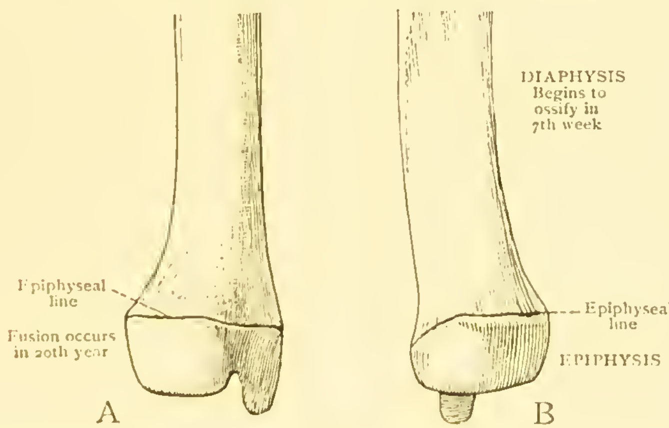

FIG. 156.—Lower end of ulna. From a subject about 17 years old. A, from behind; B, from in front. Note the single epiphysis.

The epiphysis for the *lower end* of the ulna includes the capitulum and the processus styloideus. It may be marked off by a line drawn round the bone immediately above the edge of the articular area for the radius. This epiphysis, for which there is a *single centre* of ossification, begins to ossify about the sixth year, and joins the diaphysis about the twentieth year.

Radius.—At the *upper end* of the radius, the epiphyseal line encircles the bone, at the level of the lower edge of the articular area for the incisura radialis of the ulna. The button-shaped epiphysis is derived from a *single centre* of ossification, which appears about the sixth year, and joins the diaphysis about the eighteenth year.

At the *lower end* of the bone the epiphyseal line passes round the radius at the level of the upper edge of the incisura ulnaris, and in its course crosses the summit of the little tubercle on the back of the bone which lies in relationship to the outer side of the extensor pollicis longus tendon.

The epiphysis, which is of relatively large size, includes the processus styloideus. It is ossified from a *single centre*, which appears in the second year, and it joins the diaphysis in the twenty-first to the twenty-fifth year.

Metacarpalia and Phalanges.—The arrangement of the epiphyses of the metacarpalia and phalanges is well seen in figs. 159 and 160. Omitting the os metacarpale of the thumb, each of the other metacarpalia has an *epiphysis*, which forms the capitulum of the bone.

The epiphyseal line is so disposed on the palmar or volar aspect of the bone that it closely follows the upper edge of the articular surface. On the dorsal aspect the line crosses transversely between the summits of the little tubercles to which the ligamenta collateralia of the metacarpo-phalangeal articulations are attached.

These epiphyses begin to ossify about the third year, and unite with the diaphyses about the eighteenth to the twentieth year.

The *thumb os metacarpale* differs from the others, in having the epiphysis at its base, and not at its distal end. This epiphysis begins to ossify during the third year, and becomes fused with the diaphysis in the twentieth year. In exceptional cases an epiphysis is also present for the capitulum of the thumb os metacarpale.

All the *phalanges* possess epiphyses for their proximal ends, and in each the distal end is a portion of the diaphysis. The epiphyses appear about the second or third year, and join the diaphyses about the eighteenth to the nineteenth year.

Within recent years, the study of the hand by means of X-rays has brought to light many interesting facts regarding

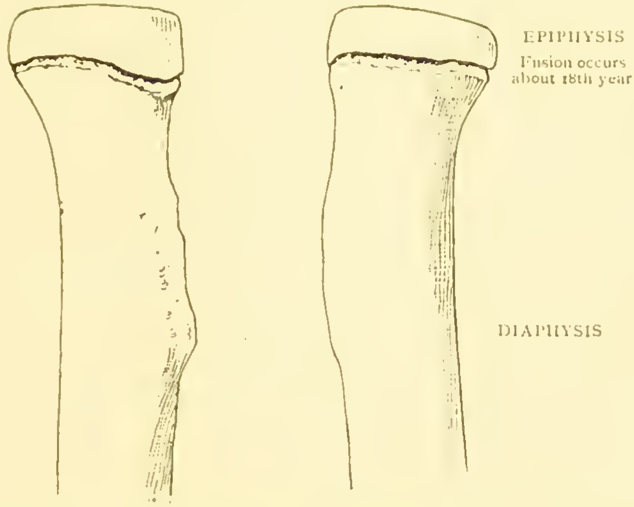

FIG. 157.—Upper end of radius. From a subject about 17 years of age. Showing single epiphysis.

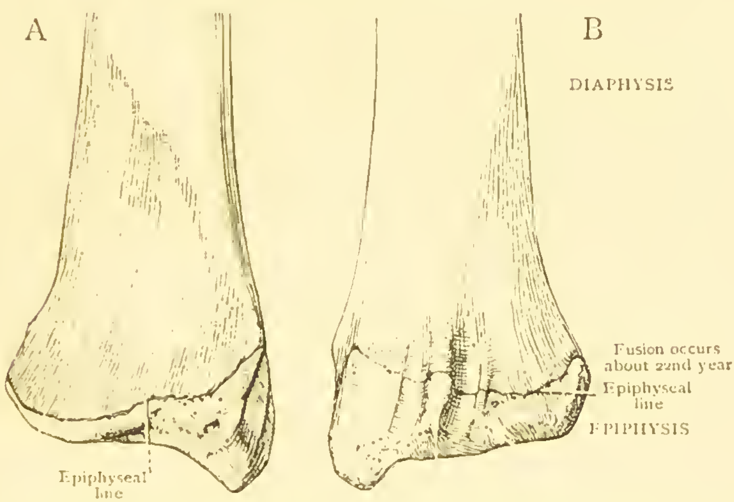

FIG. 158.—Lower end of radius. From a subject aged 17 years. A, from in front ; B, from behind. Note the single epiphysis.

its development. It has been found, for instance, that the ossification and consolidation of the finger bones is more rapid, and is completed at an earlier date, in women than in men. There is reason to believe, that in other parts of the skeleton also, a similar sex difference obtains.

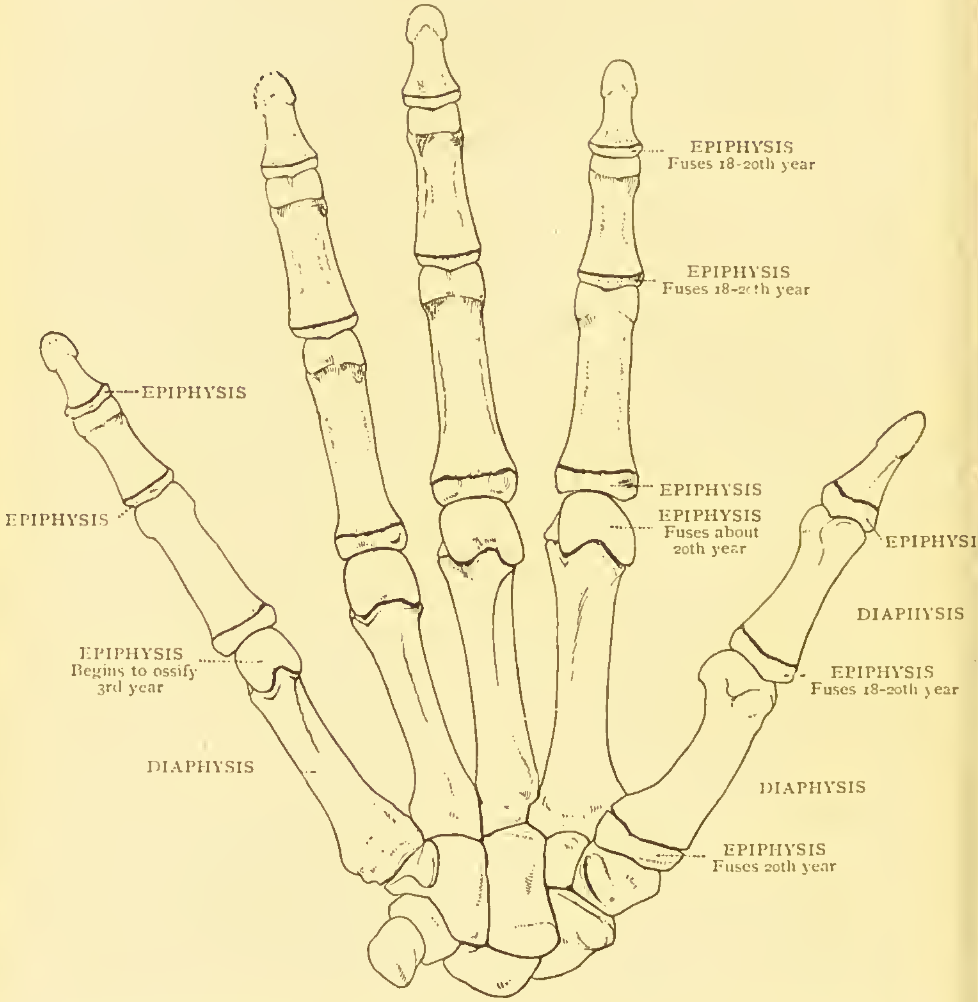

FIG. 159.—Right hand from the volar aspect, showing epiphyses of the ossa metacarpalia and phalanges. From a subject 17 years old.

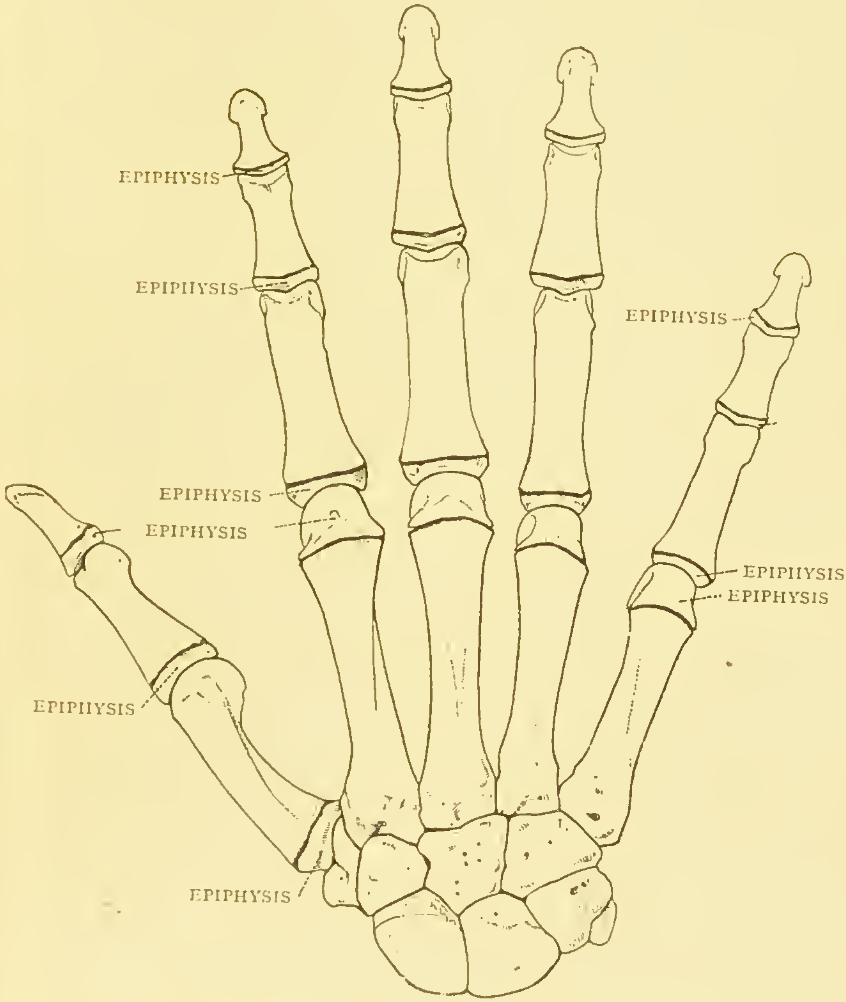

FIG. 160.—Right hand from the dorsal aspect, showing epiphyses of the ossa metacarpalia and phalanges. From a subject 17 years old.

Femur.—*Three separate epiphyses* will be found at the *upper end* of the femur: one of these forms the articular portion of the caput femoris, another forms the trochanter major, and the third forms a thick scale on the summit of the trochanter minor. In the first case the epiphyseal line follows the edge of the articular surface; in the second it accurately defines the trochanter major, and hence we find that the glutaeus medius and minimus, the obturator internus and externus, the gemellus superior and inferior, and the piriformis are all attached into this epiphysis. The epiphysis for the caput femoris begins to ossify

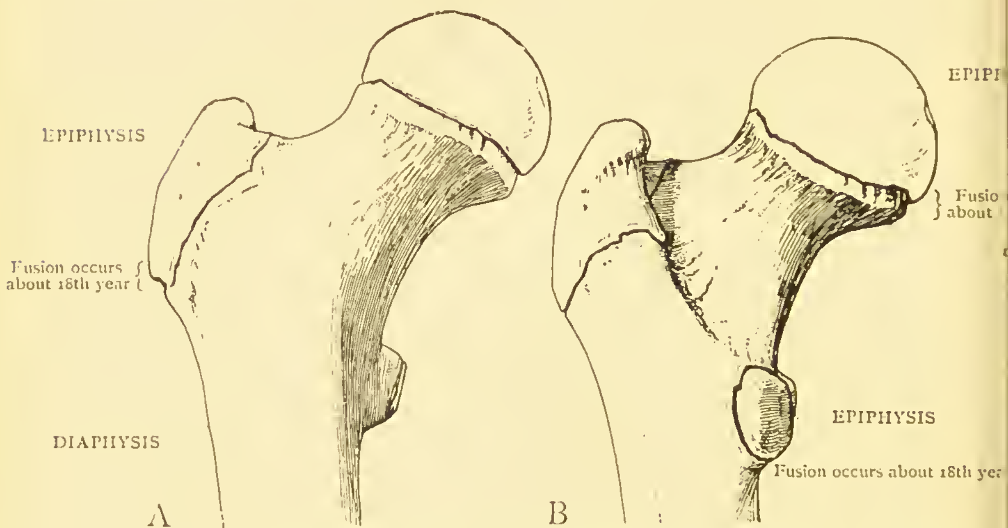

FIG. 161.—Upper ends of right and left femora. From a subject 17 years old. A, from in front; B, from behind. Note the three separate epiphyses.

early in the first year, and joins the diaphysis about the eighteenth to the twentieth year. The centre for the trochanter major appears about the third year, and the epiphysis formed from it joins the diaphysis in the eighteenth year. The epiphysis which surmounts the trochanter minor begins to ossify about the thirteenth year, and joins the diaphysis in the eighteenth year. It is evident from the arrangement of the epiphyses that the collum femoris and the greater part of the trochanter minor are derived from the diaphysis. A small scale-like epiphysis is often found on the upper part of the tuberositas glutaea which, as we have seen, is the representative of the third trochanter in other animals.

The *lower epiphysis* of the femur is of large size and is firmly morticed to the lower part of the diaphysis. Posteriorly the epiphyseal line lies at the linea intercondyloidea and passes along the upper edge of the condylus medialis and lateralis. On the anterior aspect of the bone it follows the upper edge of the facies patellaris, and on the inner and outer aspects

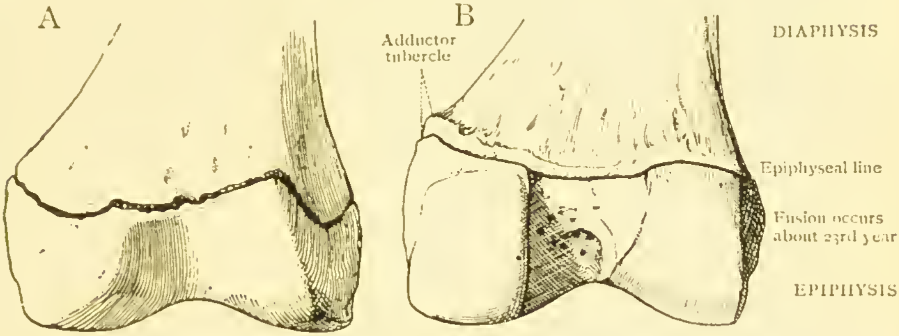

FIG. 162.—Lower ends of femora. From a subject 17 years old. A, from in front; B, from behind. Note the single large epiphysis.

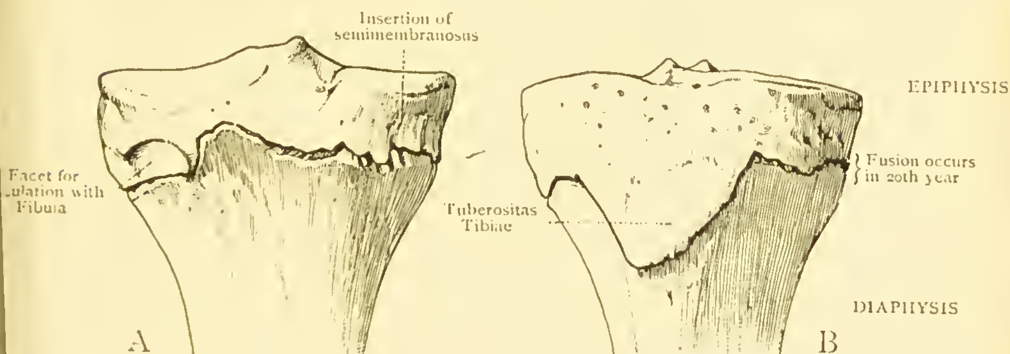

FIG. 163.—Upper end of tibia. From a subject aged 17 years. A, from behind; B, from in front.

it pursues a curved course which is convex downwards. It will be noticed that the epiphyseal line crosses the adductor tubercle.

We have already noted the important fact that the epiphysis for the *lower end* of the femur normally begins to ossify shortly *before birth*. It joins the diaphysis about the twenty-third, or twenty-fourth year.

Tibia.—The *upper epiphysis* of the tibia has a very remarkable shape. It is of large size, and extends downwards in front, so as to include the tuberositas tibiae. On the posterior aspect of the bone, the epiphyseal line runs horizontally, and lies immediately below the articular facet for the head of the fibula and the groove for the insertion of the tendon of the semi-membranosus muscle. Seen from in front the line passes downwards and describes a V, the apex of which lies at the lower part of the tuberositas. If the epiphysis be detached, it will be seen that its lower part overlaps the anterior aspect of the upper end of the diaphysis, and is merely a scale-like downward projection of the main portion of the epiphysis. The epiphysis is ossified from a centre of ossification which usually appears at, or immediately after, birth. In some cases a second centre appears much later, about the twelfth year, for the part forming the tuberositas. The epiphysis joins the diaphysis about the twenty-first year.

There is a *single epiphysis* for the *lower end* of the tibia. It is of large size and includes the malleolus medialis. The epiphyseal line will be seen to encircle the bone horizontally just above the plane determined by the upper edge of the smooth narrow area which lies below the rough surface for the strong interosseous ligament (see fig. 75). Ossification begins in the lower end of the tibia about the second year, and the epiphysis joins the diaphysis about the seventeenth, or eighteenth, year.

Fibula.—The *upper epiphysis* forms almost the entire capitulum fibulae, and includes the articular facet for the tibia. The epiphyseal line passes horizontally round the bone at the level of the lower margin of this facet. There is a *single* ossific *centre* which appears about the fourth year. The upper end of the bone becomes consolidated about the twenty-second to the twenty-fourth year.

The *lower epiphysis* forms the malleolus lateralis and bears the articular facet for the talus. The epiphyseal line passes round the bone horizontally at the level of the upper edge of this facet. The *single centre* of ossification appears in the second year, and the epiphysis becomes consolidated to the diaphysis about the twentieth year.

Metatarsalia and Phalanges.—In the arrangement of their epiphyses these bones agree in a remarkable manner with the metacarpalia and phalanges of the hand. Thus we find that each os metatarsale has a *single epiphysis* and that, except in the case of the great toe, it occurs at the distal end and forms the capitulum. In the great toe os metatarsale, as in the corresponding bone of the thumb, the epiphysis occurs at the proximal end. All the phalanges of the toes, like those of the fingers, have epiphyses at their proximal ends. (See figs. 94, 95, 96, 99, and 100.)

OTHER LONG BONES.

The ribs and clavicles must also be included in the class of long bones, although in structure, and in mode of development, they differ in many particulars from the typical long bones of the limbs.

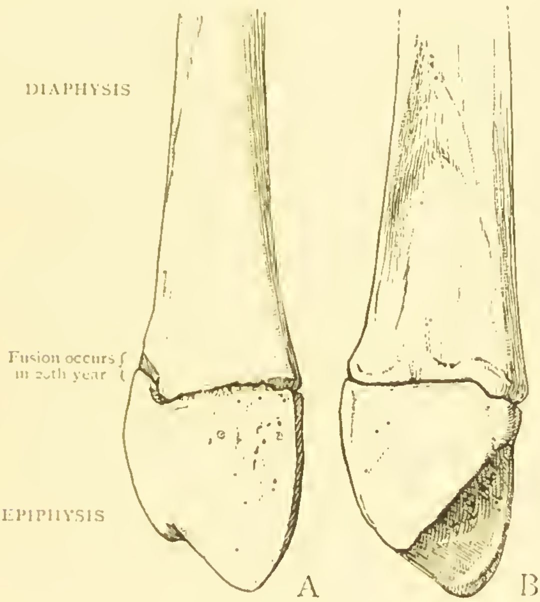

FIG. 164.—Lower end of fibula. From a subject aged 17 years. A, from the outer; B, from the inner side. Note the single epiphysis.

Costae.—Each rib consists of, (1) an outer case or shell of compact bone which is thicker and denser at the deep than at the superficial surface of the bone, and (2) an included mass of cancellous, or spongy bone. The lamellae forming the cancellous tissue lie close together in the region of the capitulum and collum costae; in the body of the rib they are more loosely arranged and include larger spaces. The marrow which fills all these spaces is of the red variety, and resembles that found in the ends of the typical long bones. The ribs are well developed at birth, and each is formed from a single centre of ossification which appears about the seventh week of intra-uterine life. At a late date—about the seventeenth year—

thin epiphyseal plates are formed and surmount the capitulum and the tuberculum. These unite with the main part of the bone in the twenty-fifth year. The epiphyseal plate for the tuberculum often consists of two portions which arise from independent ossific nuclei.

Clavicula.—It is interesting to note that the earliest formed centre of ossification which appears in the developing embryo gives rise to the clavicle. It appears early in the sixth week of development, at a time when the future clavicle is represented by dense cellular tissue which is regarded as 'a peculiar kind of cartilage'. There is reason to believe that the ossific nucleus is at first double, but if so the two parts, of which it is composed, must fuse a few days after their appearance. At birth the clavicle is well developed, and it is important to notice that there is no secondary centre of ossification until the twentieth year, when a nucleus is formed in the cartilaginous cap at the extremitas sternalis of the bone. From this a thin scale-like epiphysis is derived, which joins the shaft about the twenty-fifth year. In very rare cases an epiphysis may be found at the extremitas acromialis.

Towards its ends the clavicle is composed of spongy, or cancellous bone. The middle part of its shaft has a thick, dense wall surrounding very loose cancellous tissue.

SHORT BONES.

Ossa Brevia.—The short bones of the skeleton include the ossa carpalia, the ossa tarsalia, and the vertebrae. These all consist of spongy, or cancellous bone with a thin outer shell of compact tissue. The arrangement of the bone lamellae varies very much in the different bones, but, as in the long bones, we find in all cases that the lamellae which reach the articular surfaces are arranged in directions at right angles to these surfaces, and that the main lamellae intersect one another at right angles. The spaces in the cancellous tissue are filled during life by red marrow.

All these bones are pre-formed in cartilage, and the centres of ossification which give rise to them make their appearance in the cartilage. The dates at which ossification begins vary within wide limits; for instance, the ossific centres begin to make their appearance in the vertebrae about the eighth week of intra-uterine life, whereas one of the carpal bones, the os pisiforme, does not begin to ossify until the ninth year, or even later.

Ossa Carpalia.—We shall first consider the bones of the carpus. Each of these has a single centre of ossification which does not arise until after birth. The *os capitatum* and the *os hamatum* begin to ossify in the first year; the *os triquetrum* and the *os lunatum* about the third year; the *os naviculare* and the *os multangulum majus* in the fourth or fifth year; the *os multangulum minus* in the fifth or sixth year; and the *os pisiforme* in the ninth to the twelfth year. There is evidence to show that the ossific centres for these bones appear at slightly earlier dates in girls than in boys.

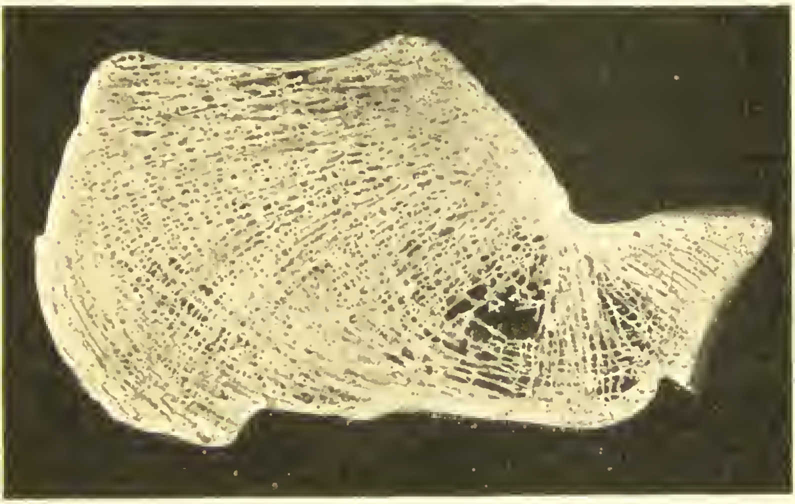

FIG. 165.—Thin sawn section through the calcaneus. The bone is composed of a mass of cancellous tissue with a thin outer shell, or cortical layer. Note the strong lamellae which correspond to the direction of the pull of the muscles inserted by the tendo Achillis.

Ossa Tarsalia.—The bones of the tarsus become ossified at an earlier date than the ossa carpalia. Two are partly ossified at birth, namely the *calcaneus* and the *talus*, their ossific centres appearing in the sixth month of foetal life.

The *os cuboideum* begins to ossify about the time of birth; the *outer os cuneiforme* in the first year; the *inner* in the second or third year; and the *middle* in the third or fourth year. The centre for the *os naviculare* is the latest to appear, and usually arises in the fourth or fifth year.

It is interesting to find that the *calcaneus*, unlike any other of the short bones of the hand or foot, possesses an epiphysis. This is derived from a centre which appears about the eighth or ninth year, and forms the posterior part of the bone into which the tendo Achillis is inserted. This epiphysis joins the main part of the bone about the eighteenth year.

Vertebrae.—Ossification begins in each vertebra by *three primary centres* which appear about the eighth week of intra-uterine life. One of these centres lies in the cartilage forming the body of the little vertebra, and the others lie one on each side in the arch. At birth each vertebra consists of three little masses of bone united by cartilage. One of these represents the corpus vertebrae, and the others form the two halves of the arcus vertebrae. During the first year, the arch in most of the vertebrae becomes completed by the fusion of its two portions in the middle line. From the third to the sixth year, the arch, so formed, unites with the body. Practically the whole vertebra is formed by the extension of the three primary centres just mentioned.

The macerated vertebrae of an infant form highly instructive objects, and their examination will enable the student to readily understand the main facts regarding the development of the vertebrae. Specimens from a subject of about seventeen years of age should also be carefully examined, as they will be found to throw much light upon the later stages of development.

A number of *secondary centres* which give rise to small epiphyses appear about the seventeenth year. The best marked of these give origin to the tip of the processus spinosus, the tips of the processus transversi, and to two thin, incomplete, disc-like scales of bone, which lie one on the upper and the other on the lower surface of the corpus vertebrae. In individual vertebrae, other minute projecting portions may arise from secondary centres, appearing at a later date.

A vertebra from a subject about seventeen years of age should be carefully examined. It will be seen that the various parts are fully developed, and the student should note the scale-like epiphyseal plates of bone on the upper and lower aspects of the corpus vertebrae, and also the minute epiphyses upon the processus spinosus and processus transversi.

The student should also identify in a young vertebra, the line of fusion between the portion formed by the arch and that formed from the centre for the body. For many years the line of fusion, or *neuro-central synchondrosis*, is marked by a groove, or cleft, on the upper and under aspect of the vertebra, and it will be noticed that this does not lie exactly

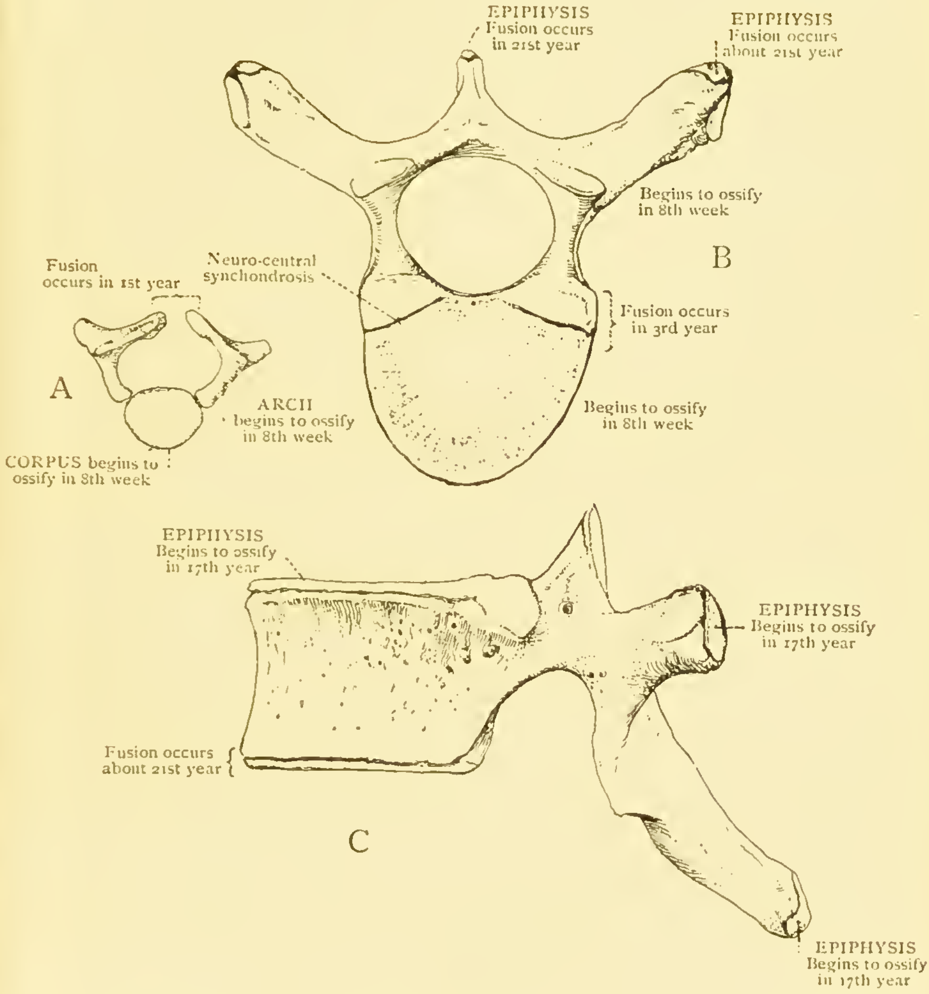

FIG. 166.—Development of vertebra. A, vertebra at birth; B, thoracic vertebra from a subject aged 17 years; C, same vertebra viewed from the left side. In B the epiphyseal plate of the corpus vertebrae has been removed.

in the region of junction of body and pedicle. From the position of the cleft it is obvious that the centres for the arch give rise, on each side, to a considerable portion of what is known in the adult as body of the vertebra. In the thoracic region, it will be found that the fovea costalis superior and inferior lie upon a part of the vertebra which arises from the centre for the arch. In the cervical region, the neuro-central union lies almost parallel to the mesial plane, and the centre which arises in the arch on each side gives origin to a relatively large portion of the body.

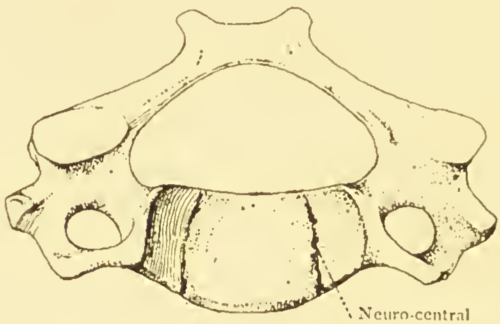

FIG. 167.—A cervical vertebra. From a subject aged 16 years.

In the *seventh cervical vertebra* a special centre of ossification appears for the anterior bar of the processus transversus, which, as we have already seen, may be represented by a cervical rib. This centre appears about the fourth month of intra-uterine life. In some lower animals the anterior bars of the other cervical vertebrae are also ossified independently, and normally remain as free cervical ribs during the life of the individual.

The *axis vertebra*, in its lower part, is ossified in the usual manner, except that the centre for the body is often double. The *odontoid process* arises in cartilage from two centres, which lie side by side, and represent the body of the first, or atlas vertebra. These centres appear about the fourth month of foetal life and, fusing together, give rise to a piece of bone, which at birth is united by cartilage only to the rest of the axis. The odontoid process does not join the body at the axis until about the fifth year. Before it has joined, a little centre of ossification appears at its apex, and gives rise to a minute mass of bone which remains separate until the twelfth year.

The *atlas vertebra* is mainly formed from two centres which give rise to the arcus posterior and massae laterales, and represent the centres for the arches found in other vertebrae. The *arcus anterior* is cartilaginous at birth, and is formed by one, sometimes two, centres which appear in the first year. About the eighth year all the parts of the vertebra have become united by bone.

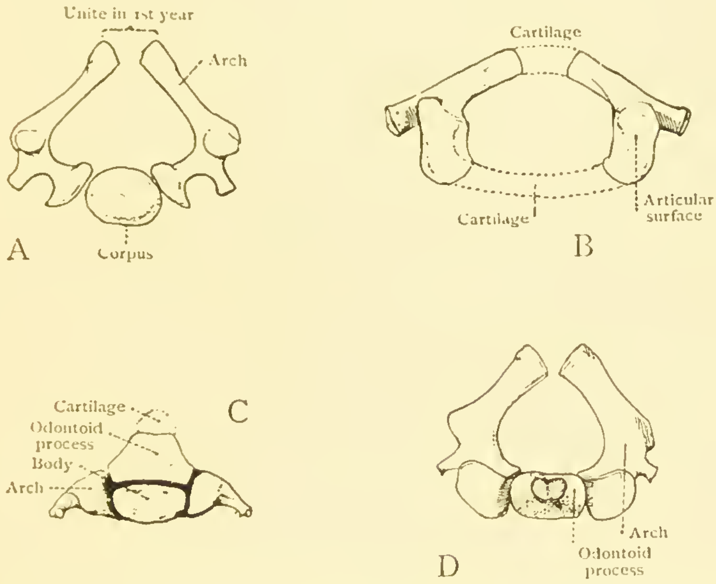

FIG. 168.—A. fourth cervical vertebra ; B, atlas ; C and D, axis vertebra. From a newly born infant.

Os Sacrum.—In the early stages of their development the sacral resemble the other vertebrae, and each is ossified from three primary centres which, however, appear later than in the upper vertebral regions. The *pars lateralis* of the os sacrum is ossified on each side from three primary centres which represent three sacral ribs, and appear about the fifth to the seventh month of intra-uterine life. At birth all these parts are represented by separate ossicles embedded in cartilage.

By the sixth year the parts of each sacral vertebra and its rib elements have united together, but for many years the vertebral origin of the sacrum is very evident, and its segments are separate, being connected only by cartilaginous and fibrous tissue.

About the seventeenth year, a series of minute epiphyses are formed for the tips of the various processes of the sacral vertebrae, and epiphyseal plates also arise for the upper and under aspects of the bodies of the vertebrae. These numerous epiphyses are well seen in the sacra of subjects about eighteen years of age. Epiphyseal scales are also formed for each facies auricularis, and for the rough edge of the sacrum lower down. These have multiple ossific nuclei.

The entire sacrum is usually consolidated about the twenty-fifth year.

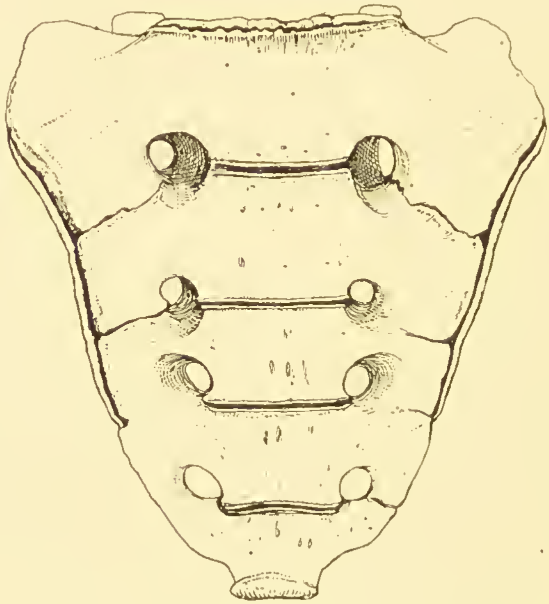

FIG. 169.—Sacrum. From a subject about 19 years of age.

Os coccygis.—Each *coccygeal vertebra* is ossified from a *single centre* which does not appear until *after birth*. The first usually appears in the first year, the last appears much later, sometimes not until the sixteenth year.

Sternum.—In its structure, and its mode of ossification, the sternum, in many particulars, resembles one of the short bones.

In an early stage of development the sternum is represented by cartilage. Ossification begins at a relatively late date, and the number of ossific nuclei and the times at which they appear vary very much. The manubrium sterni and each of the four segments of the corpus sterni are ossified independently of one another. As a rule centres of ossification have appeared in all except the last segment of the corpus sterni before birth. The last segment begins to ossify early in the first year.

One, or many centres of ossification give rise to the *manubrium sterni* and appear about the sixth month. One or two centres appear for each segment of the *corpus sterni*; as a rule one is present for the first and two for each succeeding segment. These centres arise, during the seventh to ninth months for the upper segments, and after birth for the lowest segment. The manubrium sterni usually remains separate throughout life; the segments of the corpus sterni become fused at very variable dates, from the twelfth to the twenty-fifth year. Incomplete ossification and absence of fusion may give rise to clefts, or foramina, in the corpus sterni.

Processus Xiphoideus. A single centre of ossification arises in this part of the sternum about the eighth year. Much of the cartilage normally persists throughout life, as ossification is usually not completed.

FLAT BONES.

Ossa Plana.—A majority of the flat bones occur in the skull, but two marked examples, the scapula and the os coxae, are found elsewhere in the body. Each flat bone consists of two layers of compact bone between which lies a layer of cancellous tissue. The thickness of this cancellous tissue varies much in different bones. The most typical examples of flat bones occur in the roof of the cranium; a section of one of these should be carefully examined. The bone will be found to consist of—(1) a dense **lamina externa**, or *outer table*, (2) a **lamina interna**, or *inner table*, and (3) an interposed stratum of **substantia spongiosa**, or cancellous tissue, here often called **diploë**. The spaces in the diploë are filled by highly vascular red marrow.

Scapula.—The shoulder-blade in spite of its thinness is very strong and rigid. The outer cortical layer of bone is hard and dense, and but little cancellous tissue is present except in the thicker parts of the bone. The acromion and the processus coracoideus are composed of dense cancellous tissue.

The scapula arises in cartilage from *one chief centre* of ossification which appears about the eighth week of intra-uterine life. At birth the bone has the form of a little triangular plate with a prominent crest-like ridge representing the spine. The processus coracoideus, the acromion, the angulus lateralis, and the region along the margo vertebralis, and at the angulus inferior are still composed of cartilage only. After birth, and usually in the first year, a centre of ossification appears in the cartilage forming the *processus coracoideus*; from it the main portion of this process is developed. At a considerably later period—tenth year—a second centre, the *sub-coracoid*,

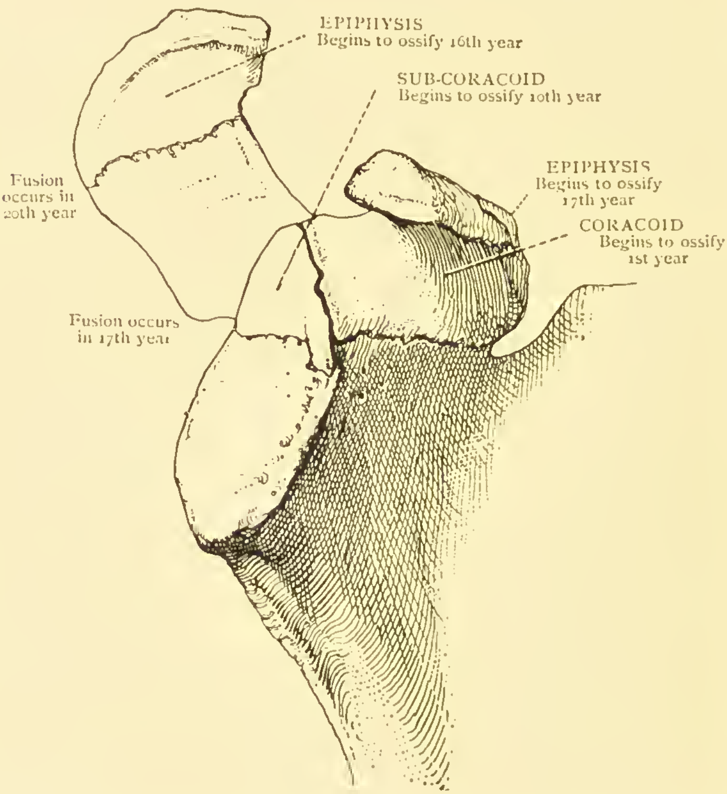

FIG. 170.—Outer part of right scapula. From a subject aged about 17 years. The scale-like epiphysis which forms the lower part of the cavitas glenoidalis is not shown.

appears in the cartilage at the base of the processus coracoideus, and from it is formed the upper part of the cavitas glenoidalis. From considerations based mainly upon observations in comparative anatomy, both these centres for the processus coracoideus are regarded as primary centres, and not as epiphyses. From the fifteenth to the eighteenth year a series of epiphyseal centres arise, and from them are formed—the acromion, the region along the margo vertebralis, the angulus inferior, the upper edge of the processus coracoideus and the surface of the cavitas glenoidalis. Usually two centres of ossification appear in the cartilage of the acromion. The processus coracoideus unites with the scapula about the seventeenth year, and all the epiphyses are united to the main part of the bone about the twenty-second, or twenty-fourth year.

Os coxae.—The outer cortical layer varies much in thickness and in density in different parts of the bone. The enclosed cancellous tissue also varies in amount, and is almost absent in the thinner parts of the os coxae. In the thicker portions the cancellous tissue is very plentiful.

Each of the three parts—os ilium, os ischii, and os pubis—which form the os coxae, is developed from a centre of ossification which arises in the cartilage of the pelvic girdle. The centre for the *os ilium* appears in the eighth week, that for the *os ischii* about the fifteenth week, and for the *os pubis* some time in the fourth or fifth month. At birth much of the os coxae is still represented by cartilage. By the eighth year, the rami of the os ischii and os pubis have fused together, but in the acetabulum the three parts of the os coxae are still united by a Y-shaped piece of cartilage. Centres of ossification are formed in this cartilage about the tenth year, and the resulting bone, or bones, and the three parts of the os coxae are usually united at the acetabulum about the seventeenth or eighteenth year. A number of scale-like epiphyses are formed about the sixteenth year, and join the main part of the os coxae during the eighteenth to the twentieth year. One of these covers the crista iliaca; another, the spina iliaca anterior inferior; a third, the tuber ischiadicum; a fourth, the articular area of the symphysis pubis. Small epiphyses covering the summit of the tuberculum pubicum and of the spina ischiadica have also been described. Some of these epiphyses are illustrated in fig. 58.

THE SKULL AT BIRTH, AND THE DEVELOPMENT OF THE SKULL BONES.

The flat bones which occur in the skull are formed, for the most part, from ossific nuclei, which appear in the membranous wall of the cranium, or in the membrane surrounding the mouth and cranial cavities. As a rule, the principal centres of ossification for all these appear about the eighth week, and from each centre the developing bone spreads outwards in a radiating manner. The condition of the flat bones which roof the cranium in the fourth month of development is well seen in fig. 152.

Many important facts may be ascertained by the examination of the skull of an infant at birth, and it will be found most convenient to use such a specimen as a foundation for the study of the development of the skull bones.

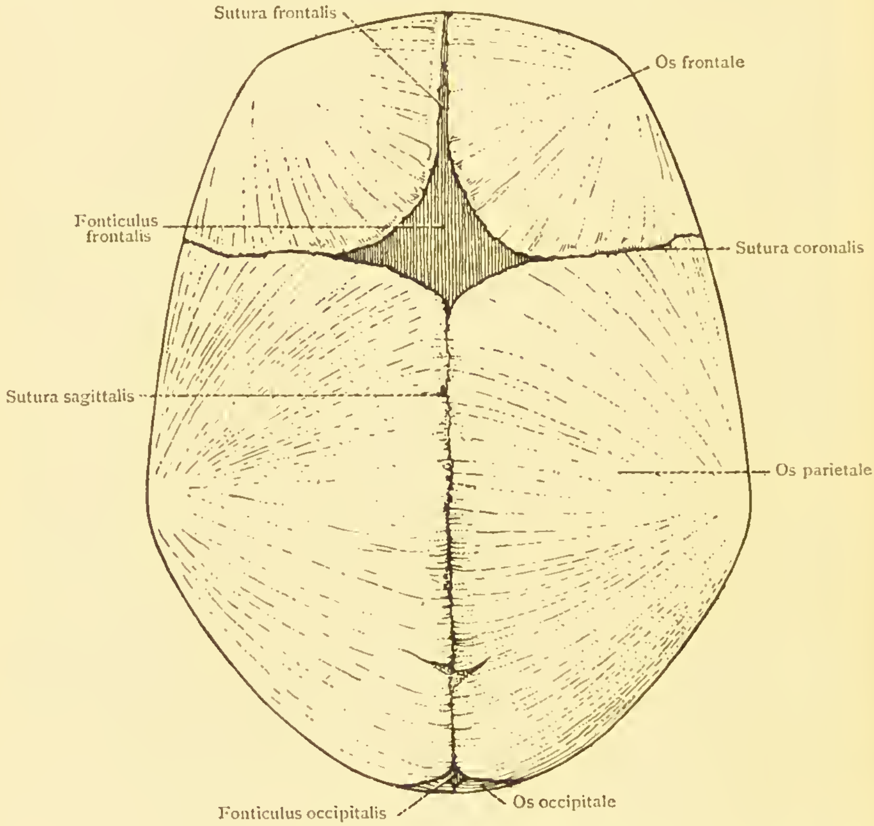

FIG. 171.—Skull at birth seen from above.

The student should carefully examine a prepared specimen of a foetal skull, and contrast its form and appearance with that of the adult.

In the skull at birth, many of the component parts, which in the adult are fused together, are still separate and united merely by cartilage or by fibrous connective tissue. On this account a certain amount of movement between the bones and moulding of the skull is permitted during parturition, as the head of the infant is forced through the pelvic outlet.

Viewed from the side, the cranial portion is seen to be relatively much larger than the facial part, in the foetal than in the adult skull.

The lines of the future suturae are occupied by narrow intervals, in which the cranial wall is completed by fibrous tissue only. The cranial bones are very thin, and their edges do not touch and interlock as they do along the suturae of the adult. At the angles of the os parietale the bony wall is very deficient, and large intervals occur where the brain is

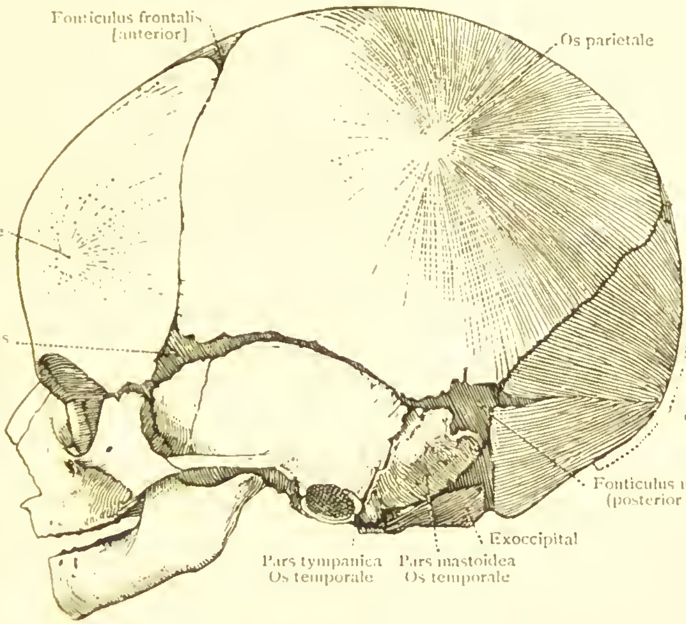

Fig. 172.—Skull of a newly born child viewed from the side.

covered only by its membranes and the layers of the scalp. These intervals are called **fonticuli**, or *fontanelles*.

The **fonticulus frontalis**, or *anterior fontanelle*, is the largest, and lies in the middle line at the junction of the frontal and parietal elements of the calvaria, in the region of the future bregma. It is important to note its outline, which is diamond-shaped, as this fonticulus can be recognized in the head of the living infant, and affords a means of identifying the position of the head before delivery.

The **fonticulus occipitalis**, or *posterior fontanelle*, also lies in the middle line; it is smaller in size, and occupies the position of the future lambda. Its outline is somewhat triangular, and, like the fonticulus frontalis, its position and form can be recognized during life.

The **fonticulus sphenoidalis**, or *anterior lateral fontanelle*, lies in the region of the anterior inferior angle of the os parietale at the pterion; and the **fonticulus mastoideus**, or *posterior lateral fontanelle*, in the region of the posterior inferior angle of the os parietale, at the asterion.

After birth the fonticuli become gradually closed by the growth of the neighbouring bones, and in normal cases they have disappeared by the end of the third year; before this time, however, they have been reduced to a very small size. Not uncommonly, little separate bones are developed to assist in completing the cranial vault, and in the adult these are often seen in the region of the pterion and asterion, and along the line of the lambdoid suture. They are known as **ossa suturarum**, or *Wormian bones*.

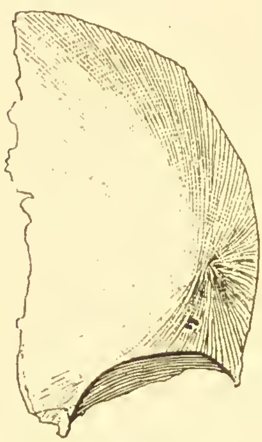

FIG. 173.—Left os frontale at birth.

It will be noticed that the *os frontale* of the adult is represented at birth by two bones, which are but loosely connected by fibrous tissue with one another and with the *ossa parietalia*. On each side of the cranium, the tuber frontale and the tuber parietale, or frontal and parietal eminences, are very prominent, and are formed by dense bone, from which a series of lines radiate towards the edges of the bone. In isolated specimens of these cranial bones it is not possible, at birth, to recognize a lamina externa, a diploë, and a lamina interna, as in the adult; nor is there any frontal air sinus. The latter does not appear until about the seventh year, and remains small until about the seventeenth year. The *os frontale* and the *os parietale* arise from centres of ossification which appear in the membranous upper part of the cranial wall about the eighth week of development.

Occipital region. The *squama occipitalis* in its upper part resembles the os parietale in structure; in its lower part, towards the foramen magnum, it is thicker, and its surface usually does not exhibit the same radiating appearance. On each side a cleft passes inwards from the lateral angle of the squama, and indicates the separation of the upper part, which is ossified in membrane, from the lower part, in which the centres of ossification arise in cartilage. The upper part is sometimes quite separate, and may remain so throughout life, forming an *os inter-parietale* such as occurs in some of the lower animals. The lower part nearly reaches the foramen magnum in the middle line, and represents the *supra-occipital* element of lower animals. The *pars lateralis*, of the os occipitale, which lies on each side of the foramen magnum forms a separate bone at birth, and is united by cartilage to the supra-occipital posteriorly, and to the *pars basilaris* in front.

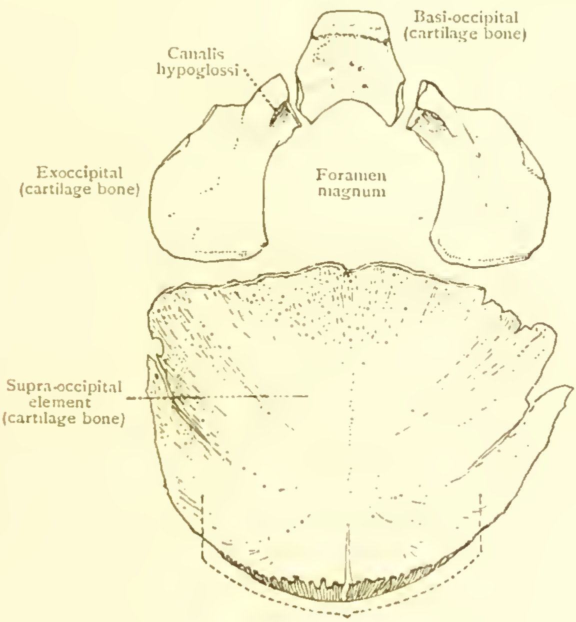

FIG. 174.—The os occipitale at birth.

The pars lateralis represents the *ex-occipital*, and the pars basilaris the *basi-occipital* bone of lower animals.

An examination of the skulls of children will show that the four separate parts of the occipital seen at birth, have usually united to form a single bone by the end of the sixth year.

From his observations on the infant skull, the student will recognize that the parts derived from the separate elements, present at birth, may be mapped out on the adult occipital bone, by drawing a line transversely from side to side, through the posterior edge of the foramen magnum, and two other obliquely directed lines, one on each side, through the anterior part of the condylus occipitalis, just in front of the canalis hypoglossi.

Os temporale. In the skull of the infant the *pars mastoidea* is flat, and there is no projecting processus mastoideus. This latter arises as an outgrowth from the pars mastoidea after birth, and may be recognized, as a projection, from the second year onwards, till the adult condition is reached. A narrow suture, the *sutura squamo-mastoidea*, separates the pars mastoidea from the *squama temporalis*; and in the macerated skull, the petro-mastoid and squamo-zygomatic parts of the os temporale form separate bones. There is no bony canal forming a meatus acusticus externus, as in the adult, but instead we find

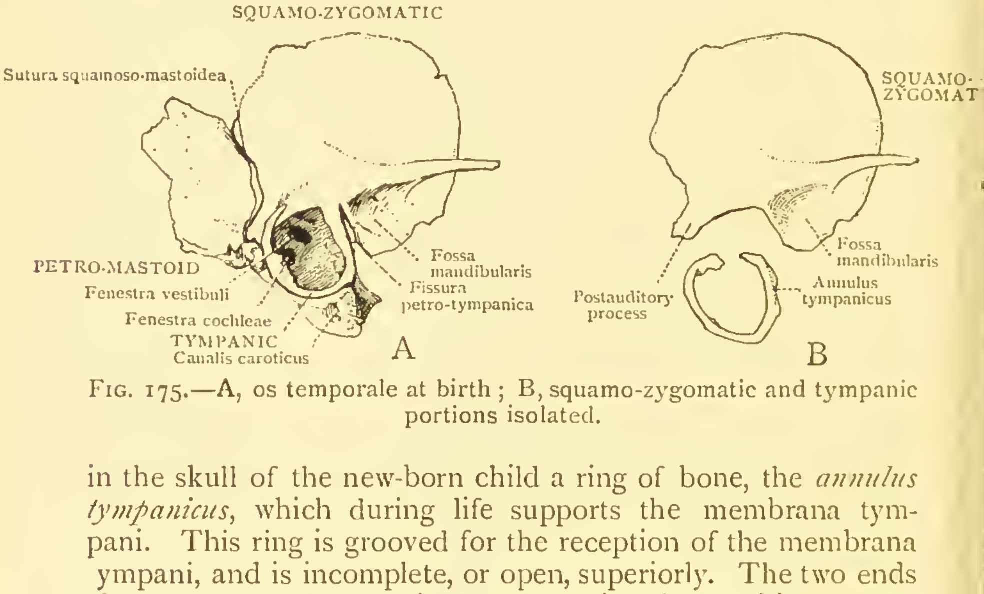

Fig. 175.—A, os temporale at birth; B, squamo-zygomatic and tympanic portions isolated.

in the skull of the new-born child a ring of bone, the *annulus tympanicus*, which during life supports the membrana tympani. This ring is grooved for the reception of the membrana ympani, and is incomplete, or open, superiorly. The two ends almost meet, and are united a short time before birth to the lower part of the outer aspect of the squamo-zygomatic just behind the fossa mandibularis.

On looking through the annulus tympanicus an excellent view of the inner wall of the cavum tympani is obtained, and one has no difficulty in recognizing the *promontorium*, the *fenestra vestibuli* (or ovalis) and the *fenestra cochleae* (or rotunda). These structures are much more easily seen in the infant's skull than in that of the adult, as in the latter, it is necessary to view them through the tube forming the meatus externus (see page 183).

The *fossa mandibularis* is very shallow at birth, and is directed outwards as well as downwards; it may, indeed, be easily overlooked. After birth, as the edge of the annulus tympanicus grows outwards to form the meatus acusticus externus, the fossa mandibularis becomes deeper and better marked.

The isolated os temporale should next be carefully examined. By detaching the squamo-zygomatic part from the petro-mastoid portion, a view of the *antrum tympanicum*, or *mastoid antrum*, can be obtained. This is a small air-space which leads backwards from the upper part of the cavum tympani. In the adult it lies deep from the surface of the bone, and communicates with the air-cells which are contained in the processus mastoideus. In the child's skull the antrum lies near the surface of

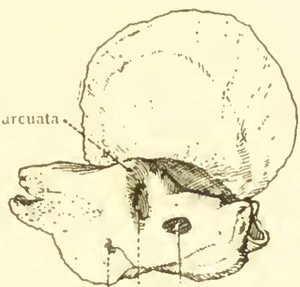

FIG. 176.—Left os temporale at birth. Viewed from the inner side.

the head, and its outer wall will be seen to be formed in part by a thin *post auditory process* of the squamo-zygomatic part of the os temporale. In the adult, owing to the growth of bone which takes place in this region, the antrum lies about half an inch from the surface of the os temporale formed by the floor of the supra-meatal triangle (see page 185).

The *foramen stylo-mastoideum* will be found on the petro-mastoid portion of the os temporale, immediately below and behind the apex of the post auditory process of the squamo-zygomatic part of the bone.

On the posterior surface of the pars petrosa of the os temporale, the *fossa sub-arcuata* is very conspicuous, and the prominence due to the semicircular canal, which arches over it, is very marked. After birth the fossa gradually becomes less and less distinct, and in the adult it is merely represented by a slight scar-like mark.

The squamo-zygomatic portion of the os temporale is ossified in the membranous wall of the early cranium ; the petro-mastoid part arises from many centres, which appear in the cartilaginous capsule of the organ of hearing; and the annulus tympanicus is ossified in the membrane closing the first gill cleft of the embryo.

The main part of the *os sphenoidale* is represented at birth by three separate bones united together by cartilage. On each side, posteriorly, we have the *ala magna* and the *processus pterygoideus* forming a single bone; in front of these and in the middle line, we have the *corpus ossis sphenoidalis* and the *ala parva* united to form a single piece of bone. The posterior surface of the body of the sphenoid is united to the anterior end of the pars basilaris of the os occipitale by a plate

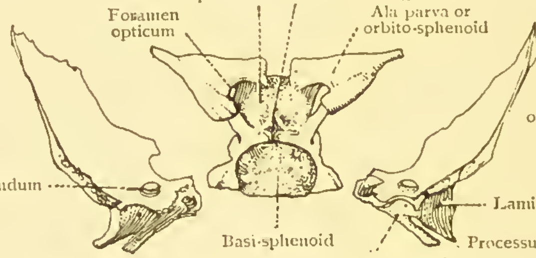

FIG. 177.—Os sphenoidale at birth.

of cartilage which usually persists until about the twentieth to the twenty-second year, and forms the synchondrosis spheno-occipitalis. At birth there is no sinus sphenoidalis; this air cavity does not arise until the seventh or eighth year. In the macerated bone, the corpus ossis sphenoidalis is pierced vertically by a canal known as the *canalis cranio-pharyngeus*, which during life is filled by cartilage and fibrous tissue. This canal is of interest in connexion with the development of the hypophysis, or pituitary body. The chief centres of ossification which appear in the cartilaginous basis cranii, and give rise to the os sphenoidale, represent the following bones which are often independent in lower animals: *prae-sphenoid* (anterior part of the body); *basi-sphenoid* (posterior part of the body); *orbito-sphenoids* (alae parvae) and *ali-sphenoids* (alae magnae). At birth, as we have seen, indications still remain of the independent origin of these parts. The *processus pterygoideus* is mainly ossified in membrane. The anterior aspect of the os sphenoidale is completed by two little bones known as **conchae sphenoidales**, or *sphenoidal turbinals*. Though separate at birth, at about the fifth or sixth year they become firmly fused to the neighbouring bones, and are no longer recognizable.

Each lateral mass, or *labyrinthus*, of the *os ethmoidale* is represented by a bony mass at birth ; but the *crista galli*, the *laminae cribrosae*, and the *lamina perpendicularis* are cartilaginous. These parts begin to ossify after birth from two centres which arise just at the base of the crista galli, and extend downwards into the cartilaginous septum and upwards into the crista galli. The ossific centres for the os ethmoidale arise in the cartilaginous nasal capsule, which in the early stages of development surrounds the nasal chambers.

The various *facial bones* are easily identified, and in general form resemble those of the adult, being of course of much smaller size. The *corpus maxillae* has very little vertical depth, and its *processus alveolaris* is as yet only partially developed. It follows that the vertical height of the face, in proportion to the cranium, is small in comparison with that found in the adult. The *sinus maxillaris* is represented by a shallow groove in the outer wall of the meatus nasi medius. The *os incisivum* is clearly marked off on the surface of the processus palatinus.

The *os palatinum* at birth is remarkable for the fact that its *pars perpendicularis* and *pars horizontalis* are approximately of equal size. This condition is to be associated with the form of the nasal chamber, which at birth is practically as wide as it is high.

The *vomer* is very deeply cleft for the reception of the cartilaginous nasal septum.

The *os nasale*, *os lacrimale*, *os zygomaticum*, and the *concha nasalis inferior* resemble those of the adult, but on a very diminutive scale. The last-named bone is ossified from a centre which appears in the wall of the cartilaginous nasal capsule ; all the others, including the maxilla, os palatinum, and vomer, are ossified in membrane.

The *mandibula* at birth is composed of two portions united together by fibrous tissue at the symphysis. The *angulus mandibulae* is very obtuse, and the apex of the *processus coronoideus* reaches to a higher level than the *capitulum mandibulae*. The *pars alveolaris* is deeply grooved to lodge the un-erupted teeth. The lower part of the *corpus mandibulae* is but slightly developed, and hence the *foramen mentale* lies relatively lower than in the adult bone.

The mandible is developed from a single centre of ossification, which arises early in the seventh week, in the membrane on the outside of Meckel's cartilage—the primitive skeleton of

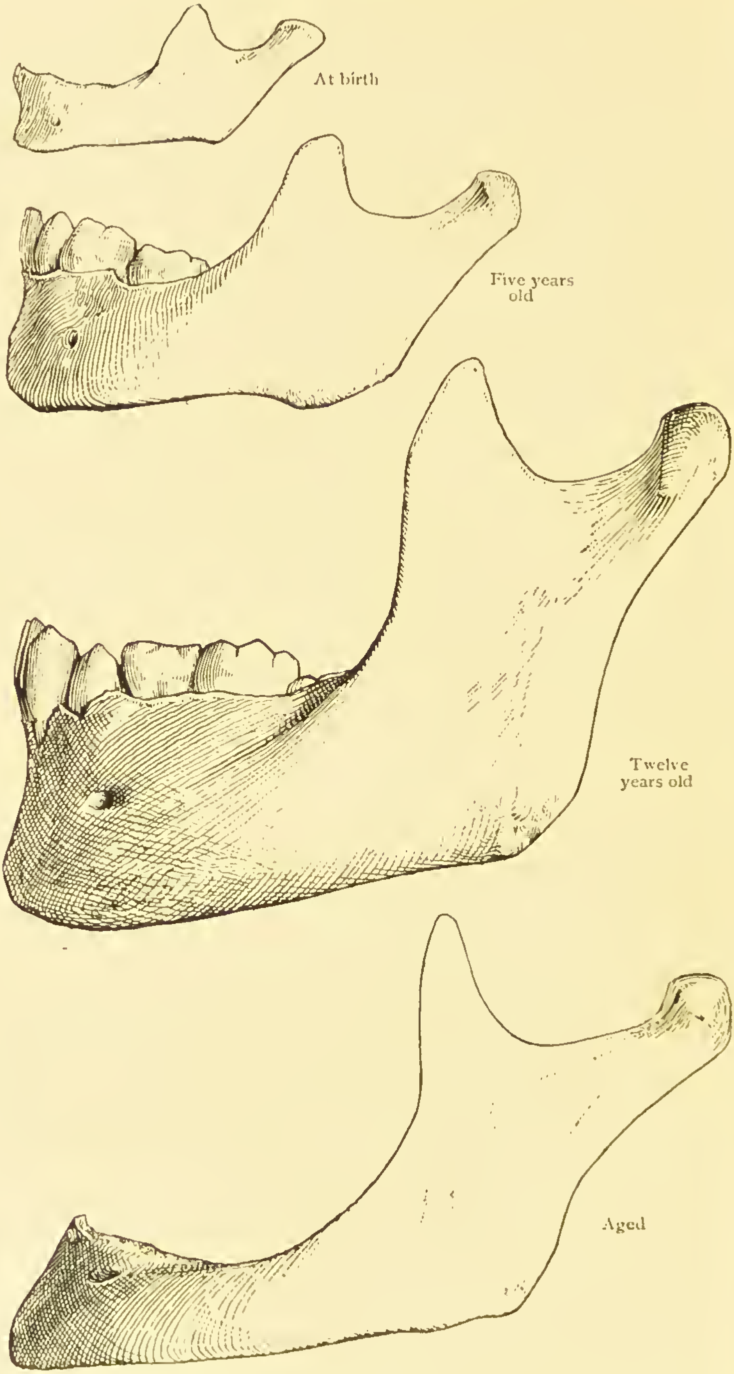

FIG. 178.—Outlines illustrating the changes in form which the mandible undergoes between infancy and old age.

the mandibular arch of the embryo. At a later date other masses of cartilage are formed in the mandibular arch, and these are invaded by the developing lower jaw; but, so far as is known, new centres of ossification do not, in the human embryo, arise in these masses of cartilage.

Bony union between the two halves of the mandible begins during the first, and is completed in the second year.

In the mandible of a young subject the angulus is still very obtuse, but when adult age is reached, it has become reduced to nearly a right angle.

In old age, as the teeth are lost, the alveolar part of the mandible is absorbed, and the foramen mentale comes to lie near the upper edge of the bone. Absorption of the bone near the angle makes the latter obtuse, and the processus coronoideus becomes slender and more pointed than in the young adult.

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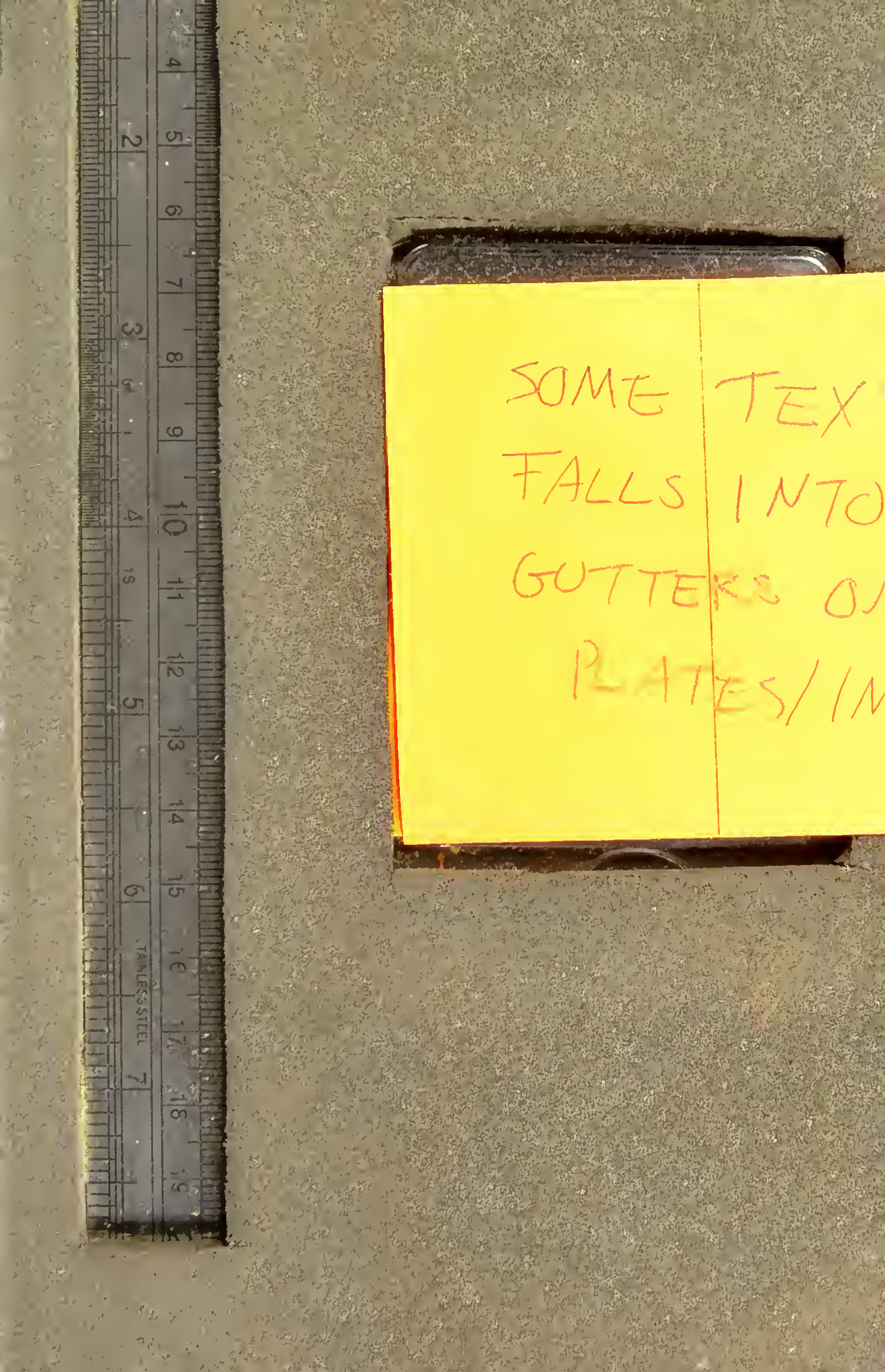
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